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TRANSPORTATION CONTROLS TO REDUCE MOTOR VEHICLE EMISSIONS IN BALTIMORE, MARYLAND

GCA Corporation

Prepared for:

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December 1972

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16. Abstracts

The document demonstrates the nature of the Air Quality problem attributed to motor vehicle operation, the magnitude of the problem and a strategy developed to neutralize these effects in order that National Ambient air quality standard may be attained and maintained.

17. Key Words and Document Analysis. 17a. Descriptors

Motor Vehicle emitted pollutants - air pollutants originating within a motor vehicle and released to the atmosphere.

National Ambient Air Quality Standards - Air Quality Standards promulgated by the Environmental Protection Agency and published as a Federal Regulation in the Federal Register.

17b. Identifiers/Open-Ended Terms

VMT - Vehicle Miles Traveled
Vehicle Mix - distribution of motor vehicle population by age group.
LDV - light duty vehicle - less than 6500 lbs.
HDV - heavy duty vehicle - greater than 6500 lbs.

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Prepared by

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GCA Technology Division
Bedford, Massachusetts

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I. INTRODUCTION AND SUMMARY

A. BACKGROUND

States were required to submit implementation plans by January 30, 1972, that contained control strategies demonstrating how the National Primary Ambient Air Quality Standards for motor-vehicle-related pollutants would be achieved by 1975. In many urban areas, the states found they could not achieve the carbon monoxide and oxidant air quality standards by 1975 or even 1977 through stationary source control and the expected emission reductions from the 1975 vehicle exhaust systems control. Major difficulty was encountered by many states in the formulation of implementation plans that included transportation control strategies, such as retrofit and inspection, gaseous fuel conversion, traffic flow improvements, increased mass transit usage, car pools, motor vehicle restraints, and work schedule changes. Because of the complex implementation problems associated with transportation controls, states were granted until February 15, 1973, to study and to select a combination of transportation controls that demonstrated how the standard would be achieved and maintained by 1977.

B. PURPOSE, SCOPE AND LIMITATIONS OF STUDY

The purpose of the study herein was to identify and develop transportation control strategies that will achieve the carbon monoxide and oxidant air quality standards required to be met by Maryland in the Baltimore area by the year 1977. Maryland's deadline extension was actually for the carbon monoxide standard only, as the implementation plan anticipated meeting the oxidant standard without transportation control strategies. On the basis of more recent and better data, this seems not to be the case, and so it is presumed that the State will request and receive an extension to 1977 for oxidants as well.

This study is one of a series, conducted in various urban areas, included to help determine the initial direction that the States should take in devising feasible and effective transportation controls, while recognizing that the control strategies outlined in this study would need to be periodically revised in the coming years. In general, the existing state implementation plans were analyzed to verify and assess the severity of the carbon monoxide and oxidant problems, and the most promising transportation controls and their likely air quality impact were determined. Major implementation obstacles were noted after discussions with those agencies responsible for implementing the controls and, finally, a surveillance review process (January, 1973-December, 1976, inclusive) was developed for EPA to use in monitoring implementation progress and air quality impact of transportation control strategies.

In the specific case of Baltimore, it developed that the needs were somewhat different than elsewhere. Prior to the beginning of the present study, the Maryland Bureau of Air Quality Control (BAQC), in the State Department of Health and Mental Hygiene, had already joined with the several local, state, and federal agencies involved in transportation planning in the Baltimore area in forming an ad hoc group known as the

Baltimore Air Quality Task Force. The Task Force's functions are to consider the air quality impact of present alternative transporation plans, and to work toward the on-going permanent incorporation of air quality considerations into the transportation planning processes of the Baltimore region. The organizations with representatives on the Task Force are listed at the beginning of Section V.

The Task Force had planned a two-phase study, the first phase of which was specifically directed toward the BAQC task of preparing plans for the February 1973 submission to EPA, but which is imbedded in a larger, longer-term framework involving the evaluation of long-term planning alternatives. Thus, the present study, and much of the consultants' effort, has been more supportive than definitive in nature, attempting to focus on detailed air quality questions and short-term (1977) planning possibilities, while remaining consistent with the broader effort.

The first purpose of this study, problem assessment, has an obvious parallel with the previous study of the problem embodied in the December 1971 revision of the Implementation Plan. While the object is the same - to define the need, if any, for traffic controls - there are at least three very major differences in the data input available for the assessment. The first of these is the availability of new pollutant emission factors based on the revised federal motor vehicle test procedure, which more accurately reflect the typical usage pattern of the urban automobile. The second major difference is the recent availability of photochemical oxidant data gethered by the reference method, which indicates that the oxidant problem is significantly more severe than was apparent from previous measurements. The third, and one which relates closely to the conduct of this study, is the use in the assessment of vehicle usage estimates generated by traffic planning procedures, in contrast to the previously-used, cruder, estimates based on gross gasoline sales data.

This last set of improved input data was the key element in the beginning of the Task Force effort to upgrade the level of transportation-air quality planning. The BMATS study, to the credit of the Baltimore area, was one of the earlier regional transportation studies (1962), and consequently, was too old to provide a desirable quality of estimate. In addition, the projected trends have not all occured, so that extrapolation was risky. Consequently, a new study, based on 1970 census data, was given a high priority by the Air Quality Task Force. In addition, resource limitations and the desire to consider a wide variety of alternatives had led the Task Force to select a new usage-estimating model, the Koppelman procedure, which could fill these needs with far less time and cost than more conventional alternatives.

Thus when the present effort began, there already existed a major effort toward the preparation of this data, and at the first few meetings, the consultants and EPA representatives agreed to await its completion. This has led to a distortion of the study schedule to the point that some elements have been treated less extensively than originally planned, but the improved data base seems clearly worth it.

Other than in the foregoing case, the scope of the study was limited to the use of data and techniques already available during the period of the study, thus requiring that a large number of assumptions were made as to the nature of future events. The 1977 air quality predictions were based on extant air quality data, on stationary source emissions already projected for the State, and on projected traffic patterns. The predictive methods themselves were often based on anticipated emission control techniques, anticipated growth patterns, and the assumed outcome of unresolved legal and political decisions. (The opening of key major traffic facilities before 1977 is particularly sensitive to the outcome of legal and political decisions.) Further, the development and ranking of transportation controls were based on extant and predicted economic, sociological, institutional and legal considerations. Thus surveillance efforts aimed at following the progress of of events based on such information must, of necessity, maintain a continuing check on the validity of the assumed pattern of future events.

C. CONTENT OF REPORT

Section II of this report describes how the pollutant concentration levels which could be expected to occur in 1977 in the Baltimore area were projected. These levels were determined by an adaptation of the proportional model using motor vehicle emissions from traffic patterns predicted for 1977 together with predicted non-vehicular emissions for 1977 obtained from state agencies. Comparison of these predicted 1977 air pollutant concentrations with the national air quality standards enabled the computation of the motor vehicle emissions which would result in the air quality standards being met, and therefore the amount of further reduction in the predicted 1977 motor vehicle emissions that would be required. In order to determine the existing pollutant concentrations, an evaluation of existing meteorological and air quality data was performed, with the final determination as to the concentration values used being made in close cooperation with representatives of the State, the Air Quality Task Force, and EPA.

Section III describes how the candidate transportation control strategies were developed and evaluated with respect to both technical effectiveness and social feasibility. An important feature of this effort was the continuing interaction between, on one hand, the GCA study team, and on the other hand, representatives of local and state environmental, planning, and transportation agencies, concerned citizens' groups, and EPA representatives.

It should be noted that some possible area-wide transit strategies were not considered because they were outside the 1977 time frame. For instance, there is a plan for the provision of rapid rail transit, but under present schedules, the first phase is not expected to be operational until 1978.

Section IV deals with the legal, institutional, social-political, and economic obstacles to implementation of the various possible strategies, although some discussion of these aspects has been necessarily included in Section III. Because of the inversion of the study schedule made to accomodate the new VMT data, the discussion considers implementation obstacles for the spectrum of strategies, rather than focusing on the specific recommendations.

Section V discusses the rationale for selecting the specific package of controls necessary to achieve the required reductions in motor vehicle emissions and presents other possibilities, both within and beyond the scope of the present study, and Section VI considers a surveillance review process by which to monitor progress toward the standard.

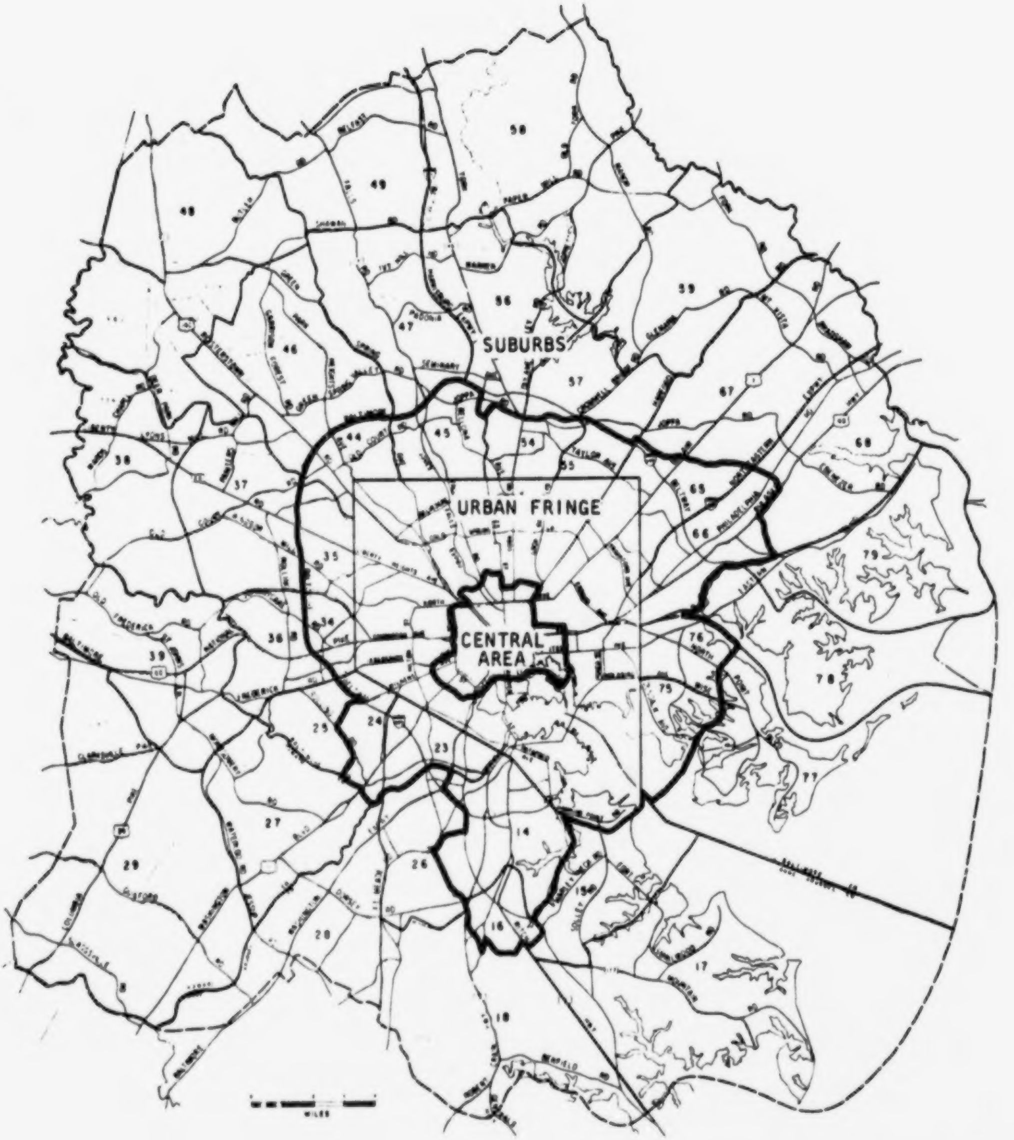
D. SUMMARY OF PROBLEM AND REQUIRED CONTROLS (BALTIMORE)

The existing air quality levels in Baltimore are monitored by two networks of sensors, one of which provided CO data at a number of sites throughout the area, the other providing oxidant data for the center city only. One network operates stations throughout the urban area and provided the carbon monoxide data used herein; after extensive validation, data was available from seven sites. The maximum 8-hourly average levels range from 20.6 ppm at a site in the center city area (though not in the CBD) to 9.9 and 7.0 ppm at outlying suburban sites. Using the empirical relation between air quality and emissions developed from these sites, it is estimated that the maximum 8-hour CO level in the densest portion of the city is about 30 ppm.

The only oxidant data available from these stations is from phenolphthalein grab samples, and in the past has generally indicated minimal oxidant problem. However, reference-method data from the new state network's center-city sites has very recently become available, and data from the summer of 1972 indicates a much more severe oxidant problem, with a maximum 1-hour level of 0.21 ppm. Thus this latter data was used for the evaluation here.

In the case of carbon monoxide, using existing air quality data and estimates of existing traffic levels, an empirical relation was developed between air quality at a site and the emission density in its vicinity. This relation was then used in conjunction with projected 1977 emission densities to predict the 1977 air quality in three separate analysis areas, as shown in Figure I-1. The results, which included the reductions through the federal Motor Vehicle Pollution Control Program, were compared with the national air quality standards to determine any further reductions required. In the case of oxidants, the standard relationship derived by EPA enabled the direct determination of the total hydrocarbon reductions required (69%) and any additional over that provided by the federal programs.

With this methodology, it was determined that the oxidant standard will not be met in 1977. The 1-hour carbon monoxide standard, which is only slightly exceeded at present, will clearly be met in 1977. The 8-hour CO standard will be met in the Urban Fringe and Suburban analysis areas, but will not be met in the Central Area in 1977 without further transportation control efforts.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MILES

Figure I-1 Baltimore Analysis Areas

The oxidant levels will require a reduction in regional total hydrocarbon emissions of around 40 percent of the already-reduced 1977 levels, which requires a 56% reduction in motor vehicle emissions. This is based on an inventory of emissions in the 6-9 a.m. period; since the problem is severe, this further refinement was felt desirable. Meeting the 8-hour CO standard in the 11-square-mile Central Area of the Region will require a 36.8 percent reduction of the already-reduced 1977 CO emission levels there, or a 38.3 percent reduction in the motor vehicle portion of the emissions. Table I-1 presents a quantitative summary of these expected emission levels and required further reductions, with 1970 emissions included for comparison.

These conclusions, and the methodology by which they were developed, represent GCA Technology Division's best assessment of the problem; neither the methodology nor the conclusions have yet been accepted by the Air Quality Task Force, although the Maryland BAQC representatives have recommended that they be so accepted. This is, no doubt, partially due to the extreme nature of the problem as developed, particularly in the case of hydrocarbons.

Despite major implementation obstacles associated with some of the candidate strategies, the severity of the problems, particularly the oxidant-hydrocarbon problem, requires the choice of all the most effective possibilities, including a retrofit program with an associated inspection and maintenance program, and the total subsidy of transit fares. The maximum possible reduction of emissions from light-duty vehicles is not com-

TABLE I-1

SUMMARY OF EXPECTED 1977 EMISSION LEVELS

	6-9 a.m. HYDROCARBONS (kg/day)	CARBON MONOXIDE $(kg/mi^2/day)$		
		CENTRAL	URBAN FRINGE	SUBURBS
1970 Total	58,850	10,281	3,787	780
1977:				
Light-duty vehicles	11,770	2,824	1,050	235
Heavy-duty vehicles	9,600	1,793	666	149
Other*	8,990	251	90	145
Total	30,360	4,868	1,806	529
AQ Std. Equivalent	18,244	3,078	3,078	3,078
Further Reduction Required	12,116	1,790	0	0

*Stationary Sources and non-gasoline vehicles pletely sufficient, so a program of evaporative and crankcase control device retrofit for heavy-duty vehicles is necessary. Specifically, the following are recommended:

1. Traffic flow improvements
2. Bus transit service improvements
3. Total subsidy of bus transit operations
4. Mandatory retrofit of uncontrolled vehicles:
    a. catalytic converters on pre-1975 light-duty vehicles
    b. crankcase and evaporative controls on pre-1973 heavy-duty vehicles
5. Annual inspection and mandatory maintenance

The detailed reductions produced and the calculation of their total effect are shown in the following Table I-2. Note that the order of their presentation is dictated by the needs of the calculations, and not by preference for the various component strategies.

TABLE I-2

RECOMMENDED CONTROL STRATEGIES AND THEIR EFFECTS

		Hydrocarbon Emissions (kg/day)		Carbon Monoxide-Central Area ($kg/mi^2/day$)	
Control Action	Effect	6-9 a.m. peak Emissions Total	Further Reduction	Emission Density	Further Reduction
1977 Expected		30,360	12,116	4,868	1,790
Traffic flow improvements to increase speed	Emissions decrease equivalent to 10% VMT reduction	- 2,162 28,198	- 2,162 9,954	- 467 4,401	- 467 1,323
Total subsidy of transit fares with associated service improvements and parking restraints	15% decrease in VMT	- 3,243 24,955	- 3,243 6,711	- 700 3,701	- 700 623
Inspection and maintenance program	Effective emission reduction: HC-4.01% and CO-3.19%*	- 650 24,305	- 650 6,061	- 112 3,589	- 112 511
Control Device Retrofit:					
a) Catalytic converters on pre-1975 light-duty vehicles	Effective emission reduction: HC-23.33% and CO-27.33%	- 3,783 20,522	- 3,783 2,278	- 957 2,632	- 957 0
b) Evaporative and crankcase control on pre-1973 heavy-duty gasoline vehicles	Reduction of hydrocarbon emissions by 6.8% of heavy-duty vehicle contribution	- 2,612 17,910	- 2,612 0	- - - No CO Effect- - -	

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* In both cases, % reductions apply to the 75% of motor vehicle emissions remaining after VMT reductions.

II. ASSESSMENT OF POTENTIAL 1977 AIR POLLUTION PROBLEM

A. OUTLINE OF METHODOLOGY

The basic procedure employed was to develop, for each city,* the potential pollutant concentration levels which could be expected in 1977 without the application of transportation controls. These levels were determined by proportional modelling using non-vehicular emissions supplied by state agencies and vehicular emissions based on traffic data developed during the course of this study. More sophisticated techniques could not be employed due to the lack of appropriate diffusion models, and the short time period of the contract, which precluded the development of a suitable model and the required inputs. Comparison of potential 1977 air quality levels with the appropriate standard gave the allowable motor vehicle emissions in 1977, which in turn formed the basis for the development of transportation control strategies.

Emissions from non-vehicular sources were obtained from state implementation plans updated as required from information supplied by state agencies. Emissions from vehicular sources were computed following the recommendations given in EPA draft publication An Interim Report on Motor Vehicle Emission Estimation by David S. Kircher and Donald P. Armstrong, dated October 1972. Air quality data for each sensor within the area was reviewed and evaluated in close cooperation with state and local agencies. Meteorological records were examined and compared with seasonal and diurnal variations in air quality levels. Finally the pollutant concentration which would form the basis for the proportional rollback calculations were decided upon in concert with state and local agencies and EPA representatives.

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* In this discussion, the word city is used to denote the urban area covered by the study and is not restricted to the area within the political limits of the city.

Because of the major differences involved, the detailed methodologies for carbon monoxide and oxidants are presented separately below.

1. Methodology for Carbon Monoxide

Because ambient concentrations of carbon monoxide at any given location appear to be highly dependent on carbon monoxide emissions in the near vicinity, it was felt that some justification existed for a modification of the proportional model. It was felt that in order to reduce ambient CO levels in, for example, a central business district (CBD), it would be more appropriate to roll back CO emissions in the CBD itself, rather than in the entire air quality region. The assumption was therefore made that pollutant concentration in any given zone was directly proportional to the emission rate of that pollutant emission within that zone. Accordingly, each city area was divided into traffic zones - about the size of the central business district (CBD) in the center of the city with increasingly larger zones towards the suburban areas. Where traffic data was already available for existing "traffic districts" the traffic zones were either the traffic districts themselves or suitable aggregations thereof; otherwise the traffic zones were based on rectangular grids.

Emission density/concentration ratios (e/c ratio) were determined for each sensor, the e/c ratio being based on the total CO emission density (expressed in kg/mi^2/day) within the zone in which the sensor was located, and the CO concentration value which formed the basis of the proportional rollback computations. Based on the e/c ratio so obtained, the maximum allowable emission density was derived which corresponded to the national air quality level to be achieved (i.e., 9 ppm for an 8-hour average), and the expected 1977 emission densities for each zone were estimated from the predicted vehicular and non-vehicular emissions for those years. Vehicular emissions were based on traffic patterns predicted for those years in the absence of any transportation controls imposed in order to meet national air quality standards for CO. Non-vehicular emissions were obtained from state implementation plans and state agencies, and take into account predicted growth and the predicted control strategies to be applied to those sources. The predicted control strategies were generally those which state agencies considered to be the maximum feasible, and therefore the predicted non-vehicular emissions were assumed to be irreducible for the purposes of this study.

From these calculations, the areas in which emissions exceeding the maximum allowable density were easily identified. On the assumption that the predicted emission densities from non-vehicular sources were to be taken as irreducible, the allowable emissions from motor vehicles in each zone for the year of interest were then determined. For the purposes of evaluating the effects of candidate transportation controls, the maximum allowable emission density for the year 1977 was expressed as a percentage reduction from the 1977 "no strategy" emission density. However, as will be seen in following sections of this report, as each traffic control was developed, emissions were recomputed, using the revised VMT's and speeds resulting from the application of the control measures.

2. Discussion of Methodology

Modified Proportional Model applications and the limitations of the conventional proportional rollback method have been well documented and reviewed[*] and need not be discussed further here. The technique used in the present study was an extension of the conventional rollback technique in the sense that it assumed first, that the constant of proportionality between emissions and concentration may be derived from emissions emanating from the relatively small area around the sensor and second, that the same constant of proportionality (the emission/concentration ratio) could be applied throughout the area to determine pollutant concentrations in other zones from the pollutant emissions in those zones.

Some justification of the first assumption can be found, for example in recent work of Hanna[**] and Gifford[***] who demonstrate the dominance of urban pollution patterns by the distribution of the local area sources. The success of their urban diffusion model, in which concentration is simply directly proportional to the area source strength and inversely proportional to wind speed, is attributed largely to the relatively uniform distribution of emission within an urban area and the rate at which the effect of an area source upon a given receptor decreases with distance.

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[*] Noel de Nevers. Rollback Modelling, Basic and Modified. Draft Document, EPA, Durham, N.C., August 1972.

[**] Hanna, S.R., "A Simple Method of Calculating Dispersion from Urban Area Sources," J. APCA 21, 774-777 (December 1971).

[***] Gifford, F.A., "Applications of a Simple Urban Pollution Model," (paper presented at the Conference on Urban Environment and Second Conference on Biometeorology of the Amer. Meteor. Soc., Oct. 31 - Nov. 2, 1972, Phila. Pa.)

In the proportional model, meteorological effects, such as wind speed, are assumed to be duplicated over one-year periods.

The validity of the second assumption depends, in large part, upon the extent to which diffusion and transport parameters are uniform from zone to zone - a factor which could not be investigated because of the constraints of the program. Thus, it was felt that, in the absence of a more sophisticated techniques, the use of this extension to the proportional model was justified first, to obtain some assessment as to whether the existing sensors were located in the hot-spots, and second, to obtain some assurance that transportation strategies intended to reduce emission densities in one zone (to the level required to meet ambient standards) did not increase emission densities to unacceptable levels in adjacent zones.

As might be expected, where an urban area had several sensors, the emission concentration ratios were widely different and this served to underline the fundamental limitations of the technique employed. An implicit assumption in the technique employed was that the air quality in a traffic zone could be fairly represented by one concentration level and that this level depended only upon the average emission density within that zone. The two major factors mitigating against this assumption are

a) Emission densities are not uniform across even a small traffic zone.

b) Concentration levels are not uniform across the traffic zone partly because of the lack of uniformity of emission density and partly because the point surface concentrations are affected by micrometeorology and microtopography as well as emission density.

Considerable judgement had to be used, therefore, both in the derivation of e/c rations and in their subsequent use. In heavily trafficked downtown areas the variation was judged not to be too great, so that the single recorded concentration might reasonably be expected to be representative of the zone's air quality and emission density. However, in suburban zones having overall low traffic densities, sensors were often found to be placed at very localized hot spots, such as a traffic circle, so that the recorded concentration levels were neither representative of the overall air quality nor of the overall emission density in the zone.

Accordingly, e/c ratios tend to be derived from sensors in the central areas of the cities and applied to suburban areas for the prediction of 1977 concentration levels. This procedure gives air quality levels which were generally representative of the suburban zones. However, it must be realized that control strategies based on this procedure while they ensure that the overall air quality in a suburban zone will not exceed ambient standards, do not preclude the occurance of higher concentrations in very localized hot spots such as might occur in the immediate vicinity of a major traffic intersection.

Seasonal and Diurnal Variations - The carbon monoxide concentration level chosen as the basis for the base year e/c ratic in any zone was, in all cases, the highest valid eight-hour average. The one-hour average either never exceeded the standard or was very much closer to the standard than the eight-hour average, so that controls required to meet the 8-hour standard would also result in the 1-hour standard being met. Motor vehicle emissions over 24 hours, 12 hours and max eight-hour periods were compared with sensor readings and the most appropriate period of time selected on which to base calculations of emission density. Although seasonal variations in readings were noted, traffic data was not available on a seasonal basis, so that vehicle emissions were based on annual average work day traffic data.

Background Concentration levels of CO were not taken into account. Where a zone was located near a large point source, simple "worst case" diffusion calculations were performed to assess the effect of the point source on the zone. In all cases, it was found that this contribution was negligible. Where a zone actually contained a large point source, its emissions were typically found to be greater than the automotive emissions within the zone and any problem in that zone was regarded as due entirely to the stationary source.

3. Methodology for Oxidants

The technique employed for oxidants was basically the same as has just been described for CO with the major difference that only one, very much larger area, was used as the basis for the proportional rollback. Because of the length of time required for the formation of oxidants from hydrocarbon emissions, the relatively small areas used as the basis for CO could not be justified. The actual area used in each city was largely a matter of judgement and the decision was made in concert with state and local officials and EPA. In general, it was about the size of the metropolitan area.

The reductions in hydrocarbon emissions necessary to achieve oxidant ambient standards were obtained from Appendix J, Federal Register of August 14, 1971.

B. PRESENT AMBIENT AIR QUALITY LEVELS

In addition to summarizing the data on ambient air quality levels in Baltimore relative to the national standards, this subsection includes an analysis of the monitoring systems producing the data in relation to their ability to provide information adequate for use in a study of the type discussed here.

1. Air Quality Monitoring Systems

Data on ambient levels of motor-vehicle-related air pollutants in the Metropolitan Baltimore AQCR is available from two separate networks. The Metropolitan Baltimore Air Quality Survey network (MBAQS network) was started in 1965 and currently includes ten stations, four in the City of Baltimore and three each in Anne Arundel and Baltimore Counties. The Statewide Air Monitoring System (AIRMON network) operates stations throughout the State, including two in the City of Baltimore, with a central data-processing facility at the offices of the Bureau of Air Quality Control, also in Baltimore. All of the twelve stations are in the relatively most urbanized portion of the Region. Station location information is presented in Table II-1; the "BMATS District" column refers to the study districts defined by the Baltimore Metropolitan Area Transportation Study, which will be used subsequently in considering the traffic data, and emission estimates.

The ten MBAQS stations are operated by the Health Departments of Baltimore City and the adjoining Counties; they measure carbon monoxide and total hydrocarbons with automatic instrumentation, and measure NO_2 and

TABLE II-1

AIR QUALITY MONITORING SITES

REFERENCE NUMBER	JURISDICTION	NAME	LOCATION	TRAFFIC DISTRICT
State Network				
1	Baltimore City	AIRMON #1	Green & Lombard Sts.	20
2		AIRMON #2	Calvert & 22nd St.	50
MBAQS Network				
11	Anne Arundel Co.	Glen Burnie	Dept. of Public Works	16
12		Riviera Bch.	R.B. Elem Sch.	17
13		Linthicum	Overlook Elem. Sch.	14
21	Baltimore County	Towson	Goucher College Serv. Bldg.	57
22		Essex	Woodward & Dorsey Ave.	78
23		Garrison	Reistertown Police Barracks	46
31	Baltimore City	Toone & Robinson	Toone & Robinson Sts.	72
32		Sun & Chesapeake	Sun & Chesapeake Sts.	13
33		Wilmarco	200 Wilmarco Ave.	21
34		Eager St.	401 E. Eager St.	50

photochemical oxidants with routinely-scheduled grab samples and wet chemical techniques. The carbon monoxide instrumentation uses the approved reference method, nondispersive infrared absorption, but the oxidant sampling is by the phenolphthalein method, which is not an approved equivalent to the reference method. The AIRMON stations, operated by the State Bureau of Air Quality Control, continuously measure CO, NO, NO_2, total hydrocarbons, CH_4, and total oxidants, all by the reference methods, and in addition, report NO_x and non-methane hydrocarbons. A detailed list of the instruments and methods used are presented as Table II-2.

Questions of data validation weigh heavily in the evaluation of the available air quality data in Baltimore. The AIRMON network has been in operation only a relatively short time, since March 1972, and so the data must be considered still subject to the extra validation judgements typical of a network's shake-down phase. On the other hand, the continuous data from the MBAQS system does not receive adequate validation under normal, routine procedures, and is generally seriously contaminated by undetected instrumentation errors, undeleted calibration runs, and so on. The State Bureau of Air Quality Control has attempted to validate the highest levels in the process of implementation planning, resulting in the deletion of sizable blocks of data. Such an after-the-fact effort by a separate agency is not a feasible substitute for proper network operation, however, and an examination of the day in-day out routine hourly average tabulations indicates that fair amounts of contamination still exist. Consequently, the choice of data to use involves

TABLE II-2

AIR QUALITY INSTRUMENTATION
(Vehicular-Related Pollutants)

POLLUTANT	METHOD	MANUFACTURER
AIRMON Stations		
Carbon Monoxide	Infrared	Intertech
Photochemical Oxidant	Chemiluminescence	
NO, NO_2, NO_x	Colorimetric-Saltzman	Linton
Total Hydrocarbons	Flame Ionization	Beckman
Methane	Subtractive Column Flame Ionization	Beckman
MBAQS Stations		
Carbon Monoxide	Infrared	Beckman
Photochemical Oxidant	Phenolphthalein	(Grab Samples)
NO_2	Colorimetric-Saltzman	(Grab Samples)
Total Hydrocarbons	Flame Ionization	Beckman

a number of judgements, based both on the relative reliability of the data as well as on the appropriateness of the analytical method; the experience of the State BAQC staff has been relied upon heavily in making these choices.

2. Carbon Monoxide

Data from both of the networks is gathered by approved, comparable infrared absorbtion techniques, so that, given appropriate precautions against interferences and good validation procedures, the data could be used interchangeably. As indicated, the MBAQS data had serious validation problems,but these are expected to be at a minimum so long as concern is restricted to the maximum levels, as is the case with the present study. The data from the two State AIRMON stations in Baltimore is available only since April, 1972; although the quality of the data appears excellent, there is as yet no data for the winter season, when the 8-hour CO levels prove to be greatest. The results from the early months of operation also indicate relatively low carbon monoxide levels, with concentrations rarely averaging as much as 10 ppm for an hour. This is believed by the State to be due to the stations' locations; both are located relatively further from significantly-travelled streets than is the typical urban monitoring site.

Consequently, the MBAQS data will be used in the subsequent analyses of carbon monoxide levels. During the period 1968-1971, the four MBAQS Baltimore City stations reported maximum 24-hour average levels ranging from 20 to 30 ppm, while the six outer stations reported maximum days around 10 to 15 ppm. The maximum hourly mean concentrations reported at the various stations ranged from 17 to 62 ppm, generally in proportion to the maximum 24-hour values; the 1-hour National Primary Air Quality Standard of 35 ppm was exceeded at the four Baltimore City Stations in the earlier years, though none did so during 1971. The early MBAQS data has not been summarized as 8-hour averages, so that direct comparison with the 8-hour National Primary Air Quality Standard is not possible. A manual examination of the unsummarized data by the State indicated that 8-hour average levels occasionally exceeded 17 ppm, and so it was presumed that the 8-hour standard of 9 ppm was exceeded fairly frequently. It is not clear that these relatively high reported levels are completely valid; a summary of maximum values is particularly susceptible to data contamination.

A more quantitative assessment of ambient carbon monoxide levels is presented in Tables II-3 and II-4, based on the most recent (and most reliable) year of data available from the MBAQS network, the twelve months from June 1971 through May 1972. The data in Table II-3 represent the highest and second highest 1-hour average CO concentrations recorded during the period. The 1-hour standard is exceeded only very rarely, and then only by slight amounts and for single isolated hours. The highest hourly averages are almost always observed at the time of the morning peak traffic period; this indicates that the cause is most likely either an unusual traffic situation on the nearby roadway or a case of a quite persistant nocturnal radiation inversion lasting through the peak traffic hour. The standard was exceeded more than once at only one station, so in view of the emission reductions anticipated from the federal control program, it is apparent that meeting the 1-hour standard by 1977 is not apt to be of concern.

TABLE II-3

MAXIMUM 1-HR AVERAGE
CO CONCENTRATIONS (PPM)
June 1971 - May 1972

	STATION	MAXIMUM VALUE (DATE)	SECOND HIGHEST (DATE)
11	Glen Burnie	51 (12/1/71)	42 (10/6/71)
12	Riviera Beach	10 (4/29/72)	10 (4/10/72)
13	Linthicum	20 (4/19/72)	17 (12/20/71)
21	Towson	15 (6/29/71)	14 (12/11/71)
22	Essex	Data Deleted As Invalid	
23	Garrison	Data Deleted As Invalid	
31	Toone & Robinson	24 (9/16/71)	23 (Twice)
32	Sun & Chesapeake	Data Deleted As Invalid	
33	Wilmarco	27 (12/16/71)	21 (12/12/71)
34	Eager St.	20 (6/16/72)	20 (4/14/72)

TABLE II-4

HIGHEST 8-HR AVERAGE CO CONCENTRATIONS

June 1971 - May 1972

STATION	CONC. (PPM)	DATE	TIME OF DAY
11 - Glen Burnie	9.9	11/12-13/71	1800-0200
	9.3	12/1/71	0000-0800
	8.5	12/20-21/71	1800-0200
	5.9	12/27/71	0400-1200
	5.3	2/15/72	0300-1100
	5.0	2/29-3/1/72	1800-0200
	4.9	4/3/72	1600-2400
12 - Riviera Beach	7.0	4/16/72	1600-2400
	7.0	5/21/72	1500-2300
	6.1	4/29/72	1600-2400
	4.3	4/10/72	0000-0800
13 - Linthicum	13.6	10/12-13/71	1800-0200
	12.9	10/30/71	0000-0800
	11.6	10/16/71	0300-1100
	11.0	10/9-10/71	1900-0300
	10.7	12/20-21/71	1800-0200
	10.5	10/29/71	0300-1100
21 - Towson	14.1	6/29-30/71	2000-0400
	10.9	8/9-10/71	2100-0500
	9.9	12/11-12/71	1900-0300
	9.1	12/20-1/71	1700-0100
22 - Essex	DATA DELETED AS INVALID		
23 - Garrison	DATA DELETED AS INVALID		
31 - Toone & Robinson	20.6	8/5-6/71	2200-0600
	20.1	9/29/71	0300-1100
	20.0	4/1-2/72	2200-0600
	18.9	1/28/72	0300-1100
	18.6	9/16/71	0300-1100
	18.6	9/24-5/71	2200-0600
32 - Sun & Chesapeake	DATA DELETED AS INVALID		
33 - Wilmarco	15.6	12/11-12/71	2100-0500
	12.9	6/29-30/71	2000-0400
	12.5	7/3-4/71	2100-0500
	12.3	2/29-3/1/72	1900-0300
34 - Eager St.	16.4	2/25/72	0800-1600
	16.0	2/24-5/72	1700-0100
	15.5	5/11/72	0200-1000
	15.4	10/29-30/71	1900-0300
	14.9	2/29/72	1600-2400
	14.4	1/3/72	1600-2400
	14.1	2/28/72	0200-1000
	14.0	1/11/72	0900-1700
	13.2	10/21-2/71	1900-0300

In contrast, most of the monitoring stations recorded 8-hour average levels well above the 8-hour standard of 9 ppm. Since the choice of control strategy, if any, necessary to reduce high 8-hour CO concentrations may depend on when and how they occur, an effort was made to determine the typical patterns of seasonal and diurnal variation in high levels, if any exist. Because of the format in which the data were available, it proved necessary to investigate the variability using hourly averages. Because of the missing and spurious data, however, it was not possible to clearly quantitate the patterns prevailing at any single site, although it was clear that there were obvious general tendencies. Seasonally, the highest maximum values tend to occur in the fall and winter months. Diurnally, the highest hourly maxima tend to occur at the time of the morning traffic peak from 7 to 9 a.m.; sustained periods of high hourly averages, however, tend to occur in the evening and overnight, during the period from 6 or 7 p.m. through 3 to 5 a.m., most often in the fall and winter. As is seen in Table II-4, the typical high 8-hour average either begins shortly after the evening traffic peak and persists till past midnight or begins sometime later, possibly lasting until the morning traffic peak. On only two occasions, January 11 and February 25, 1972, both at the Eager Street station, did a high 8-hour period occur through the day, including some of both morning and evening traffic.

Thought of in terms of the known diurnal patterns in the motor vehicle traffic that produces the carbon monoxide, this seems at first somewhat unusual, as the overnight hours are clearly the time of least traffic. The reason for this seeming contradiction is, of course, the daily pattern of changes in meteorological dispersion; during mid-day, when traffic volume is high, the capacity of the atmosphere to disperse pollutants is also at it's highest, with turbulent mixing and relatively higher wind speeds. In contrast, the evening hours typically present poorer dispersion, with frequent stable, nonturbulent conditions and generally lower wind speeds, all at a time when traffic volumes are still sizable. In the winter, with its early sunset, the poor dispersion conditions are often "closing in" at the same time as the evening traffic peak, or shortly after. Thus, it is not surprising to find the worst 8-hour CO levels on early winter evenings. Figure II-1 presents data for one such period when several of the stations recorded relatively high CO levels. The levels began increasing in late afternoon, and then the highest period began just with the evening traffic. The weather was warm, but rainy and then cloudy all day, so there was relatively little sunlight-induced turbulence; overnight and Tuesday morning, the winds were under 3 miles per hour and it was very foggy. In the late afternoon on Tuesday, a front came through and the weather became suddenly clear and fairly windy; this is readily seen in the graph as the abrupt decrease in carbon monxide levels around 4:00 p.m., and the bare hint of a peak corresponding to the evening rush hour. Noting the date in Figure II-1, it is apparent that another factor contributed to the high levels - the last week of Christmas shopping. This also helps emphasize the role of meteorological dispersion; the evening traffic on Tuesday was surely at least roughly comparable to that on Monday, yet the excellent dispersion has reduced ambient levels to near zero.

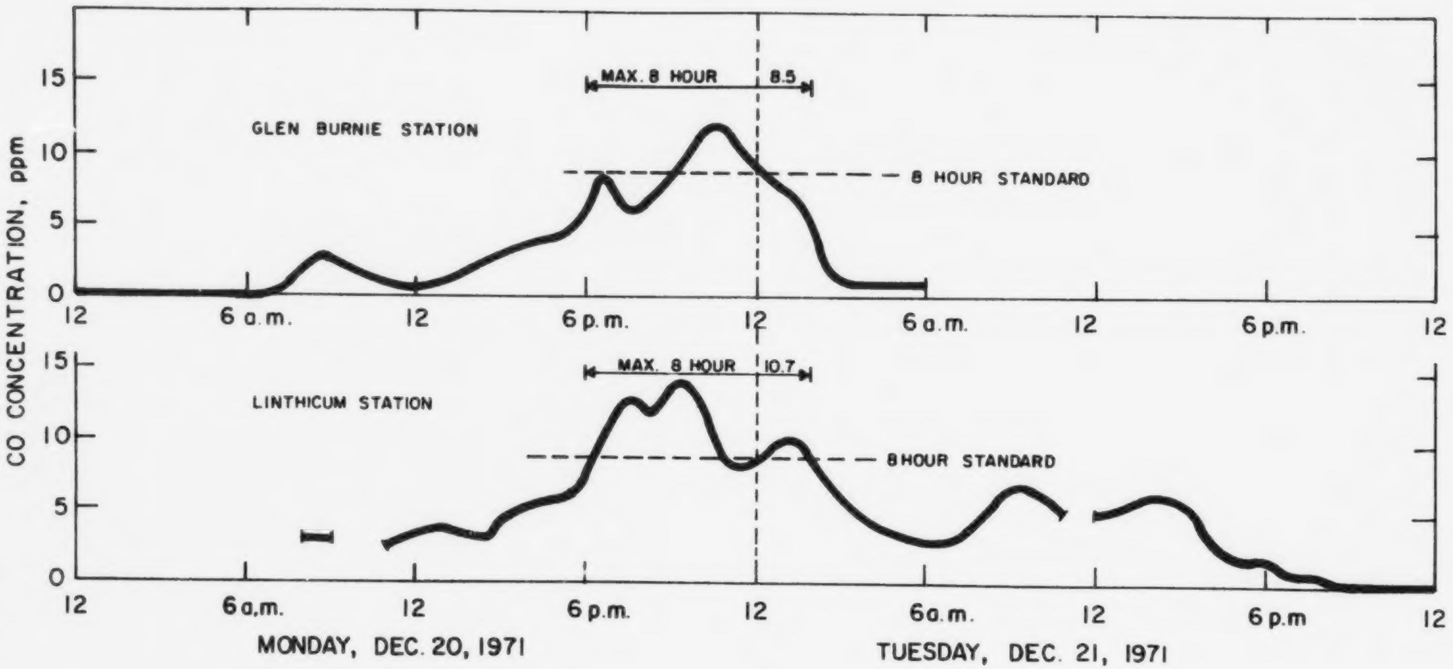

Figure II-1. Typical Overnight High 8-hour CC Levels.

The data in Figure II-1 was chosen because it illustrated the point clearly; it is not from the stations with the highest levels, nor were the days involved the highest at the stations. The shape of the variation overnight is, however, quite typical of the high 8-hour average CO levels found at the several stations.

3. Photochemical Oxidants

With respect to photochemical oxidants, there is less data available; the MBAQS stations continuously record total hydrocarbon levels, but measure oxidant only with grab samples and phenolphthalein wet chemistry, which is not an approved equivalent to the chemiluminescence reference method. The two AIRMON stations have reference method oxidant instruments and methane instruments, but their data is available only since March 1972.

The 10-minute phenolphthalein oxidant data from the MBAQS station is summarized in Table II-5, including the equivalent 1-hour potassium iodide (KI) values, obtained by dividing by the "standard" correction factor of 2 and a peak-to-mean factor of 1.1. Taking these KI equivalent levels at face value, it appears that maximum oxidants levels are approximately at or just below the 0.08 ppm standard, rather uniformly so throughout the area. The one station with a distinctly-higher maximum also recorded other high values, so there is no evidence for concluding the maximum is an anomaly. This station, in Riviera Beach, is generally downwind of the central business district and the harbor industrial area, so it likely is just reflecting the influence of these areas on days with appropriate meteor-

TABLE II-5

MAXIMUM 1-HR OXIDANT LEVELS
MBAQS STATIONS, 1969-71

STATION	MAXIMUM CONCENTRATION (PPM) PHENOLPHTHALEIN (10-minute)	MAXIMUM CONCENTRATION (PPM) KI EQUIVALENT (1-Hour)
11 - Glen Burnie	0.128	0.058
12 - Riviera Beach	0.256	0.115
13 - Linthicum	0.171	0.077
21 - Towson	0.177	0.080
22 - Essex	0.138	0.062
23 - Garrison	0.118	0.053
31 - Toone & Robinson	0.103	0.046
32 - Sun & Chesapeake	0.144	0.065
33 - Wilmarco	0.172	0.077
34 - Read St.	0.149	0.067

ology. It was on the basis of this oxidant information that the State's original implementation plan concluded that the 1-hour oxidant standard would be just met by 1975 through the federal motor vehicle control programs and stationary source controls.

The chemiluminesence oxidant instruments at the AIRMON stations have only been operating since March 1972, and hence only the 1972 summer is really available for determining maximum levels. The oxidant levels over 0.08 ppm are tabulated in Table II-6. The highest hourly oxidant level recorded was 0.21 ppm on August 26, 1972, and the second highest 0.20 ppm on July 19, 1972, both at the AIRMON #2 station. The instruments have proven quite satisfactory, and there is no reason whatever to question the data; thus, since the data is gathered by the reference method, it was decided to consider the levels determined at the AIRMON sites as the ones that should be compared with the standard, despite the short history of the data. The availability of this data significantly modified the assessment of the present oxidant problem, from a situation with maximum levels typically near the standard to one with maximum levels well over twice the standard, and it presumably will prove to be impossible to meet the standard by 1975, as was previously thought.

With respect to the MBAQS data, two possibilities arise; the data can be discarded, or we could choose to consider the phenolphthalein data as defining patterns of spatial variations. The maximum value of 0.115 ppm at the Riviera Beach site is 1.80 times the 0.064 ppm average

TABLE II-6

1-HOUR OXIDANT CONCENTRATIONS OVER 0.08 PPM

AIRMON STATIONS

	DATE	MAXIMUM 1-HOUR CONC.	TIME OF DAY EXCEEDED
STATION 1	June 4	0.09	2-3p.m.
(Green & Lombard Sts.)	July 2	0.10	2-4p.m.
	July 14	0.11	12-3p.m.
	July 17	0.10	12-1p.m.
	July 19	0.10	12-3p.m.
	Aug 26	0.12	1-4p.m.
STATION 2	May 18	0.09	2-3p.m.
(Calvert & 22nd St.)	May 22	0.13	12-3p.m.
	May 23	0.09	2-4p.m.
	May 24	0.13	11a.m.-7p.m.
	June 3	0.11	11a.m.-6p.m.
	June 4	0.14	10a.m.-5p.m.
	June 16	0.10	12-1p.m.
	June 30	0.11	11-12a.m.
	July 11	0.12	12-1p.m.
	July 14	0.19	11a.m.-3p.m.
	July 15	0.10	11a.m.-1p.m.
	July 16	0.10	11a.m.-3p.m.
	July 17	0.12	11a.m.-11p.m.
	July 18	0.12	1-2p.m.
	July 19	0.20	9a.m.-6p.m.
	July 20	0.12	10a.m.-11p.m.
	July 21	0.11	11a.m.-11p.m.
	Aug 11	0.09	2-3p.m.
	Aug 12	0.13	12-5p.m.
	Aug 26	0.21	11a.m.-5p.m.
	Aug 27	0.09	12-2p.m.

of the maximum values at the four Baltimore City sites. To estimate the maximum and second-highest hourly average at the Riviera Beach station, this ratio, interpreted as measuring a geographical pattern, can be applied to the maximum and second-highest hourly average values from the Baltimore City AIRMON stations. If this were done, the estimated maximum and second-highest hourly oxidant levels for the Region would be about 0.38 and 0.36 ppm respectively. It was decided, however, not to make use of the MBAQS data in this way. While the concept of using the data to establish a pattern for geographical extrapolation is fairly sound, and the phenolphthalein data appears internally consistent and of good quality, the striking difference in numerical values is too great to overlook. The fault is very possibly in the "well-established" conversion factor, which perhaps should be more carefully considered. As it turns out in the present case, the maximum levels of 0.21 ppm raise serious difficulties in meeting the standard, so that the question of extrapolating to a higher value becomes largely a moot point.

As was the case with carbon monoxide, it is desirable to have some knowledge of the type of meteorological conditions under which high oxidant levels occur, in order to properly consider potential control strategies. Fortunately, knowledge of the gross mechanisms of oxidant formation is relatively well developed, although precise quantitative relationships may not be available. The days on which the highest hourly average oxidant levels occur are days with plenty of sunshine, clear skies or very little cloudiness, and high temperatures, as expected. The wind direction varies, typically from west to north, but occasionally shifting in the afternoon, perhaps indicating the formation of a sea breeze. Afternoon wind speed is not generally light, but is seldom over 12 mph; earlier wind speeds are generally slower, though this would be typical of any day. Most of the high levels are recorded at the AIRMON 2 station north of the center city; the oxidant levels at Station 1, to the southwest, seem to be consistently lower. However, even though the absolute value of the levels differs, the correlation between the two stations is excellent; this would imply that the differences are real geographic differences. however caused, rather than being reflections on the quality of the data.

4. Conclusions

In very brief summary, the present air quality levels in Baltimore reflect rather widespread violation of the 8-hour carbon monoxide standard, and quite sizable violation of the oxidant standard. The data on which these appraisals are made are subject to some criticism in the case of CO, but are in general adequate when viewed from the perspective of the typical data quality in a number of cities.

C. VEHICLE-MILES OF TRAVEL

Estimating the emissions from a population of vehicles requires some measure of the amount they are driven; since the emission factors are available in terms of grams per mile (per vehicle), the measure commonly used is vehicle-miles of travel (VMT). In addition to VMT data, the source-emission relationship requires information on travel speed and on the age distribution and vehicle-type mix of the vehicle population.

1. Assessment of Traffic Data Base

The most critical of the inputs is the VMT information. In order to make most use of the extensive air quality data and to provide a rational basis for considering transportation control strategies affecting sub-areas of the Region, it was necessary to have emissions, and hence VMT estimates, on a relatively-fine scale, comparable at least to the scale of areas in which strategies might be considered.

There were three general methods available for producing this information from the available base data, specifically:

- Use of current traffic data as a base condition, with projections based on trendline analysis.
- Use of the standard urban transportation planning methodology, consisting of a set of chain models including trip generation, trip distribution, modal split, and traffic assignment.
- Use of an aggregate level, direct assignment type model, which would output VMT without going through the conventional model chain.

The first method was considered too gross for the analysis at hand. The second was the most desirable from the technical point of view, but because of the relatively high cost and time requirements of this procedure, it was beyond the scope of the present contract. There exists 1962 and 1980 VMT data produced by this methodology as part of the Baltimore Metropolitan Area Transportation Study (BMATS) and interpolation of this data was considered. However, discussions with local officials suggested that the projected data had not, in fact, accurately predicted the actual historical growth trends. The third approach had considerable appeal, as it seemed to meet the data requirements with the proper scale of analysis for input to the emission models. In addition, such a model, which could produce both VMT and speed estimates, was already being programmed for use by the Maryland Bureau of Air Quality Control, and the results of their efforts would be available for use in this study. Thus, this procedure was selected for the development of transportation data. Since a variety of the necessary data was available for 1970, it was decided to use 1970 as the "present" or base year for the computation and to use as data-base areas the Districts defined previously for the BMATS study, Figures II-2 and II-3.

2. The Koppelman Model and VMT Calculations

The model used to estimate 1970 and 1977 vehicle miles of travel and speed by facility type was developed by the Tri-State Transportation Commission under the direction of Frank S. Koppelman.* Although primarily a highway needs model, designed as an aid in making highway investment decisions, the Koppelman procedure contains sub-models which estimate the parameters of interest to the air quality models.

For the New York City region, a regression model** was developed to relate vehicle miles of travel density, vehicle trip origin density, and expressway supply. The VMT model is summarized by:

$$\text{VMT} = 64.3\ (\text{VTE}^{0.74})\ (e^{1.6\ \text{FE/FO}})$$

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* Frank S. Koppelman, A Model for Highway Needs Evaluation, Highway Research Record No. 314, Highway Research Board, Washington, D.C. 1970.

** Tri-State Transportation Commission, A Model for Highway Needs Evaluation, Interim Technical Report 4157-2490, New York, 1969.

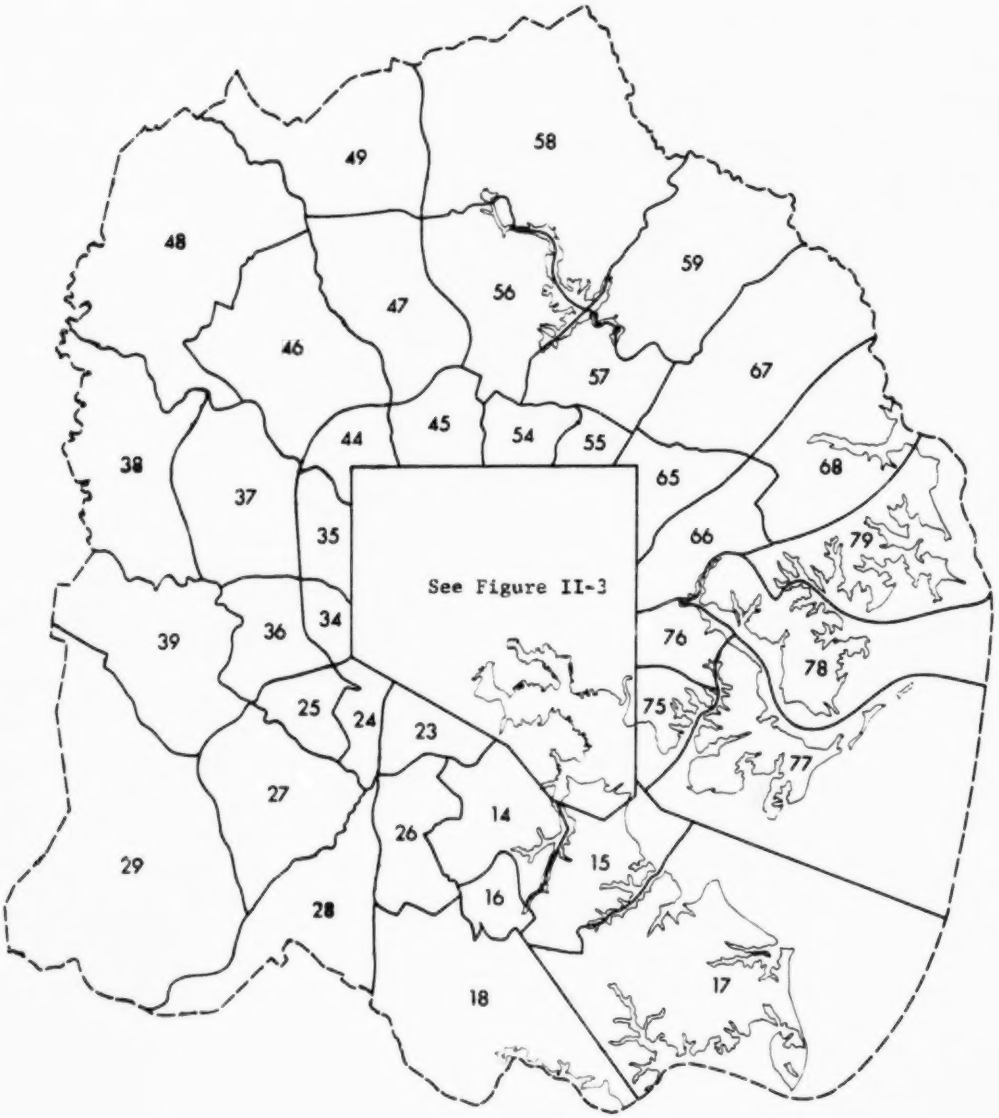
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Figure II-2 Baltimore Metropolitan Area Transportation Study (BMATS) Districts

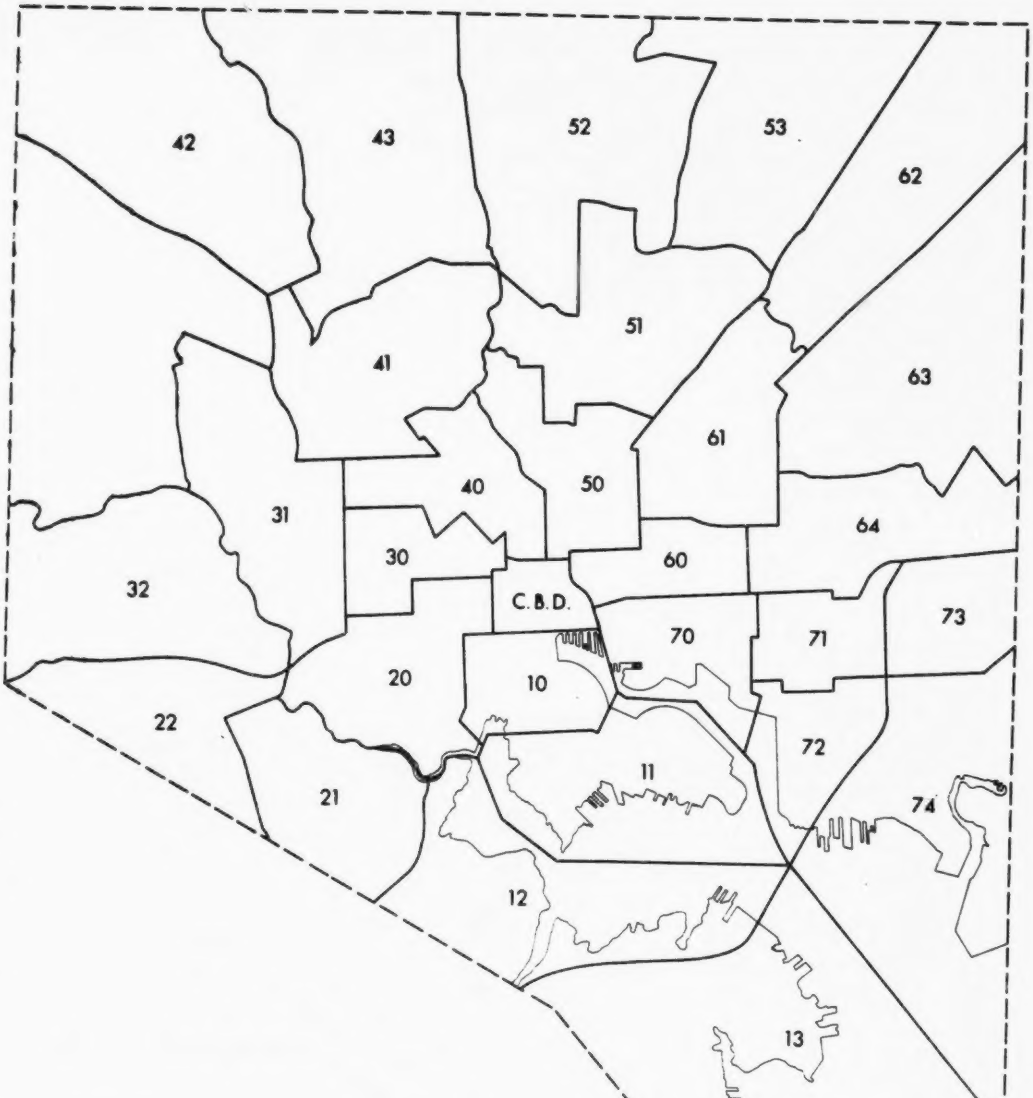
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Figure II-3 Baltimore Metropolitan Area Transportation Study (BMATS) Districts-Baltimore City

where:

VMT = vehicle miles of travel per square mile

VTE = vehicle trip ends per square mile

FE = foot-miles of expressway per square mile

FO = foot-miles of locals and arterials per square mile

Relationships were also developed between average speed, traffic volumes, and trip ends:

$$\text{SPD-EXP} = 55.3 - 0.73\ \text{VLE} - 5.19 \log \text{VTE}$$

$$\text{SPD-ART} = 32.7 - 1.21\ \text{VLA} - 8.64 \log \text{VTE}$$

$$\text{SPD-LOC} = 18.9 - 6.5 \log \text{VTE}$$

where:

SPD-EXP = average speed on expressways

SPD-ART = average speed on arterials

SPD-LOC = average speed on local streets

VLE = average volume per lane on expressways in thousands

VLA = average volume per lane on arterials in thousands

VTE = average vehicle trip ends per square mile in thousands

These two submodels were used by Berwager and Wickstrom as part of a macro-level auto emissions model for the Washington, D.C. area. Based on the Washington experience, the Maryland Bureau of Air Quality Control decided to use this procedure in conjunction with their own emissions model to evaluate alternative future highway systems. Thus, when this study was initiated, the general framework had already been established, with the Koppelman model as an integral part. It was agreed at the first formal

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[*] Sydney D. Berwager and George V. Wickstrom, Estimating Auto Emissions of Alternative Transportation Systems, Metropolitan Washington Council of Governments, Washington, D.C., 1972.

meeting held by EPA with the consultants and local officials that use of this model should be continued. Because the equations, developed originally for New York City, had provided a reasonable fit to the Washington data, no separate calibration was performed to relate the model structure to Baltimore.

Inputs to the Koppelman Model

Vehicle trip end density and foot miles of expressways, arterials, and local streets was required for each BMATS district to project 1970 and 1977 VMT with the Koppelman model. Vehicle trip ends were interpolated from the 1962-1980 projections of the BMATS study. The BMATS trip ends were calculated on the basis of composite 1962 auto-transit truck trips. 1970 and 1977 estimates of foot miles for each highway type were obtained from current and projected highway network data provided by the Regional Planning Council. Data on average volume per lane on expressways and arterials, which the Koppelman model uses to estimate average speeds, was derived from the Highway Capacity Manual relationships.* A description of the 1970 and 1977 highway network, which forms the basis of input to the Koppelman model, is included below.

1970 and 1977 Highway Networks

The 1970 base highway network, as updated by the Maryland Department of Transportation for the region, was used for the 1970 estimates, including all freeways, arterials, and major collector and local streets in each BMATS district. No rapid transit links were expected to be complated by 1977; the 1977 transportation network was assumed to be simply the same basic highway system, with the addition of some links in the Interstate system within Baltimore city.

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*Highway Research Board, Highway Capacity Manual, Special Report No. 87, 1965.

Figure II-4 is a map of the Baltimore City portion of the adopted Interstate highway plan for the area, popularly termed the "3-A System," showing the links included in the 1977 analyses. Although it was assumed that these links will be operational by 1977, it must be emphasized that all of them are presently in some stage of litigation and/or environmental impact review, and several other sections in the system have not yet entered the location or design stage of the planning process. Thus the assumptions regarding the additional completed links, which were provided by the Interstate Division for Baltimore City, must be viewed as "optimistic", with much depending on the outcome of the various lawsuits.

The highway facilities assumed to be operational by 1977 were:

(1) I-70N (Leakin Park Expressway) to Hilton Parkway

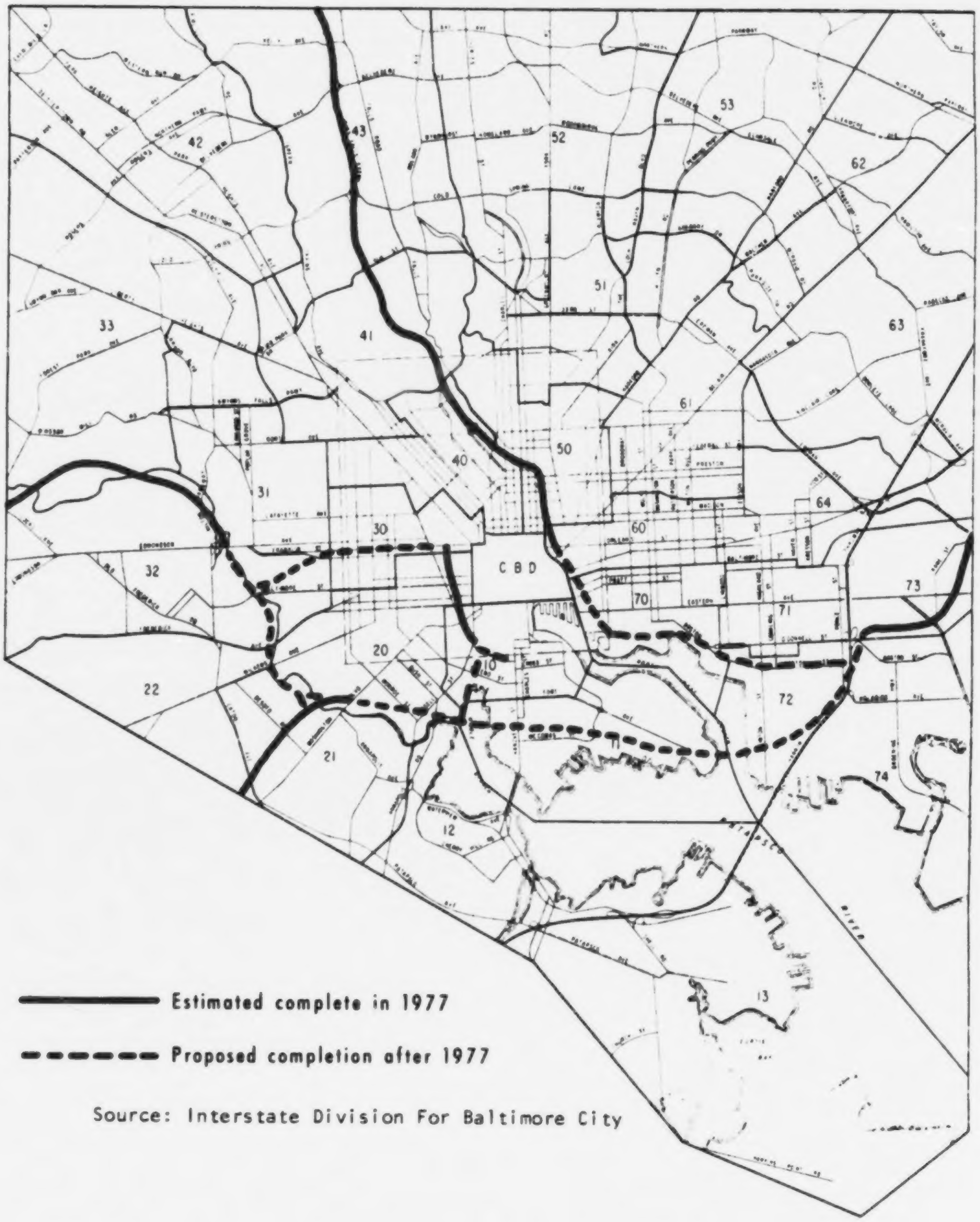
(2) I-83 (Jones Falls Expressway) to Gay Street

(3) I-95 (northern section) to O'Donnell Street

(4) I-95 (southern section) to Washington Boulevard

(5) Central Boulevard, Mulberry Street to Russell Street

The other segments of the Interstate system were not expected to be completed until 1978 or later and, again, it was assumed that none of the rail rapid transit system would be operational by 1977.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Estimated complete in 1977
Proposed completion after 1977

Source: Interstate Division For Baltimore City

Figure II-4 Baltimore Interstate Highway Network, 1977

Results

The Maryland Bureau of Air Quality Control programmed and ran the Koppelman model on facilities at the University of Maryland. The data inputs were monitored and reviewed by the Air Quality Task Force and the consultants, as were the results. The Koppelman model output included VMT and average speeds by facility type for each District. Figures II-5 and II-6 display these outputs, for 1970 and 1977, in terms of VMT density as a function of distance from the central business district (CBD). Although individual points exhibit considerable variation, the results are reasonable in the light of general experience. Figure II-7 summarizes the general growth from 1970 to 1977. Based on the Koppelman procedures, regional VMT densities are expected to increase approximately 40 percent during this period.

3. Factors for Vehicle Type

Because the input trip ends were composite data including travel by heavy-duty vehicles, the output data also include truck travel, so it was necessary to factor the VMT estimates into vehicle type. Heavy-duty VMT was analyzed using several information sources to develop estimates of the portion of VMT attributable to light-duty gasoline vehicles (6,000 lbs. GVW or less), heavy-duty gasoline vehicles (over 6,000 lbs.) and non-gasoline vehicles. The latter category was derived from fuel tax data for the State of Maryland; heavy-duty gasoline vehicles were estimated from BMATS figures, adjusted for diesel, and interpolated for 1970 and 1977. The factors used are tabulated in Table II-7; the Bureau of Air

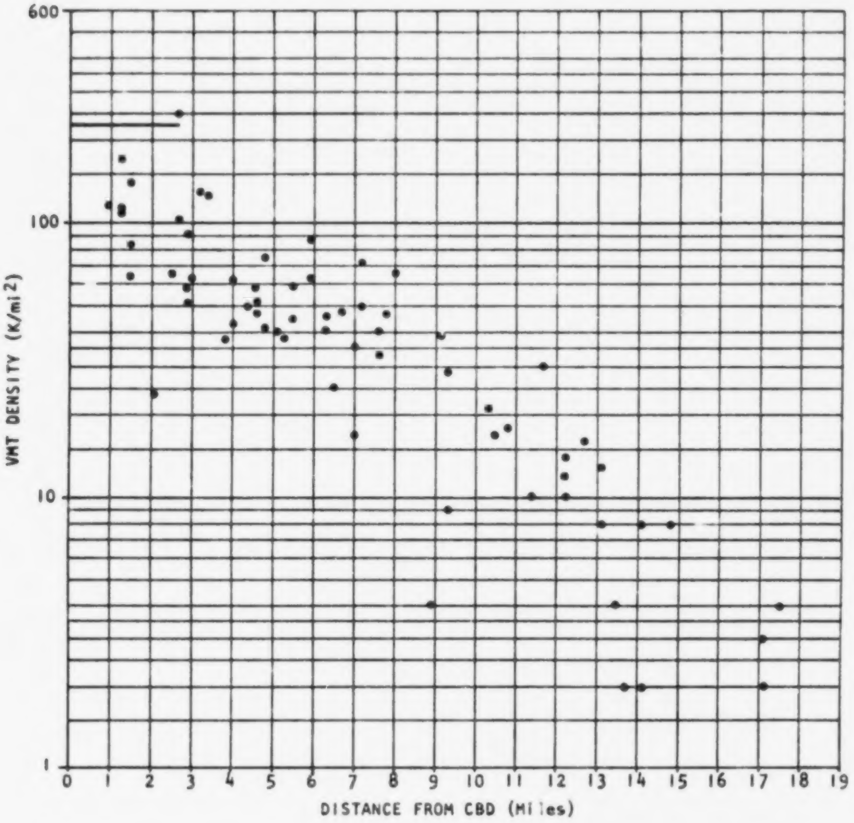

Figure II-5 VMT density (K/mi^2) vs. distance from CBD (Miles)
Baltimore 1970

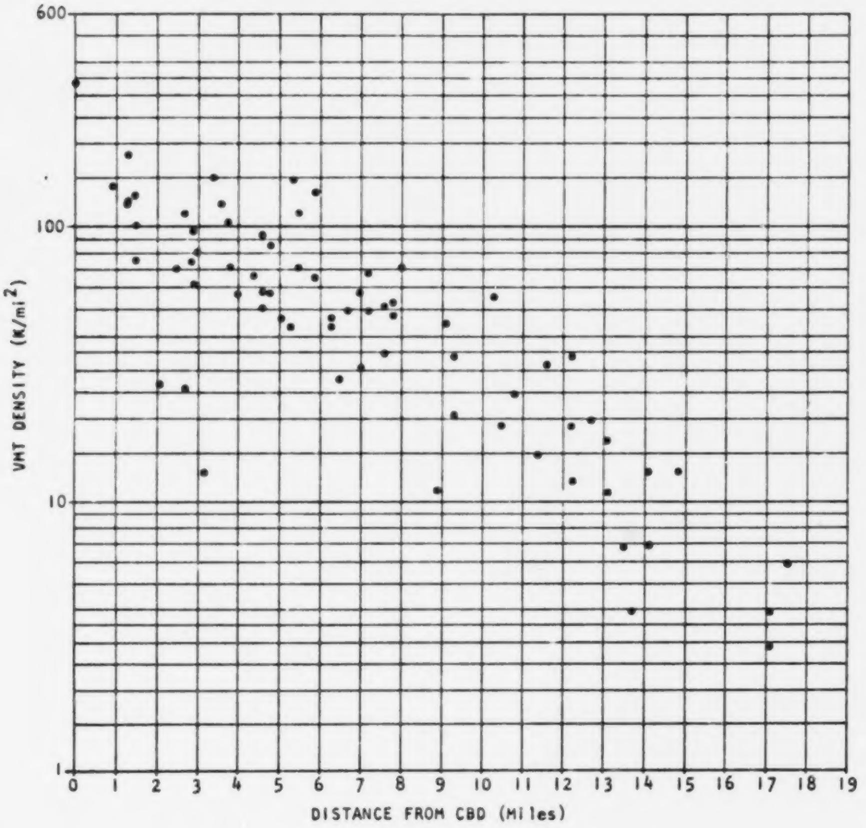

Figure II-6 VMT density (K/mi^2) vs. distance from CBD (Miles)

Baltimore 1977

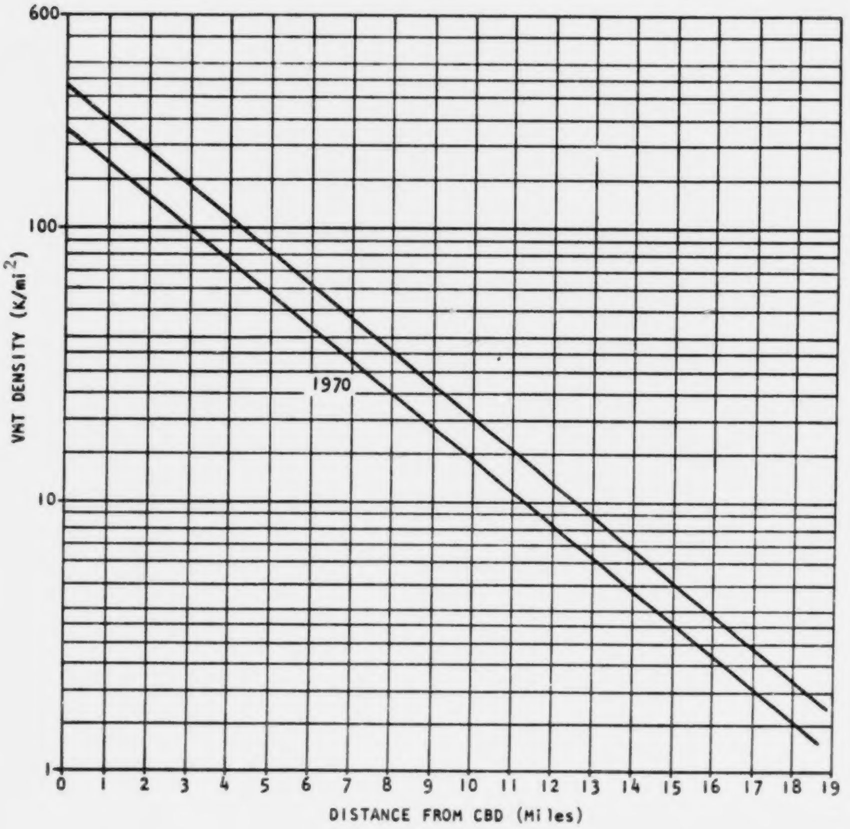

Figure II-7 Comparison of 1970-1977 VMT Densities.

TABLE II-7

VEHICLE-TYPE FACTORS FOR BALTIMORE AREA VMT DATA

	1970 Percent	1977 Percent[*]
Light Duty Gasoline	88.9	86.0
Heavy Duty Gasoline	9.9	12.5
Heavy Duty Diesel	1.2	1.5
	100.0	100.0

[*] Assumes 26 percent growth in truck registrations and corresponding travel based on U.S. Department of Transportation estimates.

Quality Control obtained similar estimates using a procedure related to national statistics. The VMT estimates, by facility type, vehicle type, and District, are tabulated in Appendix A, not only for the basic 24-hour average weekday, but also for peak-hour and maximum 12-hour periods.

It is important to keep in mind that the Koppelman procedure produces its estimates based on empirical regressions on input parameters expressed as geographical densities, rather than from any input that makes use of the fact that the highway system has a network structure. Because of this, it is quite sensitive to the level of aggregation of the input, i.e., the size of the geographical areas over which the input and output densities are computed, and totally insensitive to the logical "connectedness" of the highway pattern. The Koppelman estimates of VMT, as shown in Appendix A, cannot be considered valid at the District aggregation level, except possibly in the larger suburban Districts. They are, however, assumed to be valid for use in analysis at a broader level of aggregation. For purposes of determining the emissions-air quality relationship, the BMATS Districts were aggregated into clusters in the vicinity of the air quality monitoring sites. For purposes of future air quality projections and for the analysis of candidate transportation control strategies, the Districts were aggregated into three concentric rings centered upon the central business distric (CBD). These rings, labelled Central, Urban Fringe, and Suburbs, were jointly defined by the Air Quality Task Force and the consultants as shown in Figure I-1 they are subsequently referred to as "analysis areas".

4. Vehicle Age Distribution Data

Beyond VMT and speed data, the emission-estimation process requires knowledge of the distribution of VMT among various model year vehicles, in order to accurately take into account the changes in emission factors. This information is a combination of the age distribution of vehicles and the differences in the mileage driven by vehicles of various ages. Vehicle age distribution data are available from two sources: (1) the Maryland State Motor Vehicle Administration and (2) R. L. Polk & Company, a commercial survey firm. Basic data from these sources are tabulated in Appendix B, R.L. Polk data for automobiles and trucks separately, and State data for all vehicles. Table II-8 below includestwo sets of vehicle-age and average-mileage distributions. The data is from the sources noted, and the age-distribution data has been

TABLE II-8

DISTRIBUTIONS OF VMT BY VEHICLE AGE

	POLK DATA USED IN PRESENT STUDY				MARYLAND STATE DATA	
	Passenger Cars		Trucks		All Vehicles	
Vehicle Age (years)	Vehicle Distribution[a] (Percent)	Average Travel[b] (Miles)	Vehicle Distribution[a] (Percent)	Average Travel[b] (Miles)	Vehicle Distribution[c] (Percent)	Average Travel[c] (Miles)
0	3.2	3,600	3.0	3,500	4.1	3,300
1	12.2	11,900	10.8	11,700	11.8	12,900
2	15.8	16,100	13.5	17,200	11.5	11,750
3	11.9	13,200	10.7	15,800	10.5	10,650
4	10.2	11,400	8.3	15,800	9.3	9,550
5	9.3	11,700	8.1	13,000	9.5	9,225
6	9.1	10,000	7.7	13,000	9.2	8,675
7	8.2	10,300	6.4	11,000	7.7	8,475
8	6.7	8,600	5.3	11,000	6.5	7,900
9	5.0	10,900	4.2	9,000	6.0	7,225
10	3.2	8,000	3.3	9,000	5.0	6,675
11	1.8	6,500	2.5	5,500	4.0	5,200
12	1.1	6,500	2.2	5,500	4.9	4,500
13	2.3	6,500	14.0	5,500		
	100.0		100.0		100.0	

(a) GCA Adjustment to R.L. Polk data in Table B-1

(b) Kircher & Armstrong, 1972, quoting AMA Publications

(c) Maryland BAQC Modification of data in Table B-2

(d) Bureau of Public Roads data quoted by Maryland BAQC

TABLE II-9

POLLUTANT EMISSIONS FROM MOTOR VEHICLES BY ANALYSIS AREA AND VEHICLE TYPE

By Analysis Area:	Carbon Monoxide (kg/day)		Percent Change	Hydrocarbons (kg/day)		Percent Change
	1970	1977		1970	1977	
Central area	108,450	50,085	-54			
Fringe area	609,393	283,778	-53			
Suburban area	396,695	234,333	-41			
Total BMATS Area	1,114,541	568,196		182,288	86,497	-53
By Vehicle Type:						
Light-Duty Gasoline	905,145	343,630	-62	141,578	47,062	067
Heavy-Duty Gasoline	205,309	218,338	+ 6	40,038	38,411	- 4
Other	4,087	6,228	+52	672	1,024	+52
Total	1,114,541	568,196		182,288	86,497	

Note: The values for the total area are those calculated for the entire area as a single piece; they differ slightly from the sum of the District-level results because of the non-linearity of the speed adjustment factor. To avoid confusion, the emissions in the Suburban area have been determined by difference so that the tables will sum properly.

adjusted from that in Appendix B to account for the difference between the mid-year vehicle counts available and the end-of-year distributions desired.

The distribution based on R.L. Polk data was used for both 1970 and 1977 emissions estimates herein. The second set of distributions was used by the State Bureau of Air Quality Control for their calculations, and is included to provide some perspective on the magnitude of variation in such data.

D. POLLUTANT EMISSIONS

1. Emissions from Motor Vehicles

Given the estimated 1970 population of motor vehicles, or more specifically, their usage in the form of estimated vehicle miles travelled (VMT), estimating emissions can be done with empirical relationships, the classic emission factors. In the case of motor vehicles, the emission factors are a function of the model year of the vehicle (the initial control devices and emission level), the age of the vehicle (deterioration), and the vehicle speed. Data on the distribution of vehicles by age can be used to incorporate the first two factors, while vehicle speeds must be estimated on the basis of traffic engineering procedures. In the present case, vehicle age distribution data was available from the Maryland State Motor Vehicle Administration for all vehicles, and from the commercial survey firm of R.L. Polk and Co. for light- and heavy-duty vehicles separately as tabulated in Table II-8; in the subsequent emission calculations herein, the Polk data were used.

Basic emission factors by model year (in grams per vehicle mile) and adjustment factors for deterioration and speed were taken from the EPA draft document* provided. A computer program incorporating these relationships was prepared and used to calculate emission estimates from the VMT and speed data produced by the Koppelman procedure. Such calculations were made for each of the 68 BMATS Districts, as well as for the total study area; these are tabulated in Appendix C. In the case of CO, these District-level emission estimates were then summed to provide the totals for the three analysis areas as tabulated in Table II-9.

2. Stationary Source Emission

Although motor vehicles produce the larger portion of the carbon monoxide and hydrocarbon emissions in the Baltimore region, there are sizable stationary sources and non-automotive vehicular sources, and they become increasingly significant as automotive emissions are reduced. Estimated annual emissions from such sources in 1970 were about 95,000 tons of carbon monoxide and about 58,000 tons of hydrocarbons, representing respectively about 18 and 45 percent of the totals for the region, as tabulated in Tables II-10 and II-11.

For purposes of this effort, the major stationary source CO emissions were included in the appropriate BMATS District, to be included for density-calculation purposes in that District only. The emissions from the smaller point sources of CO were distributed into the three analysis areas

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*Kircher & Armstrong, 1972.

TABLE II- 10

CARBON MONOXIDE EMISSIONS

Source Category	1970			1977		
	tons/year	kg/day	%	tons/year	kg/day	%
Non-Automotive (1)						
Power plants	1,345	3,350	0.2	350	870	0.1
Refuse disposal	3,070	7,650	0.6	1,300	3,240	0.4
Space heating	4,535	11,300	0.8	3,500	8,700	1.1
Shipping, etc.	10,320	25,700	1.9	11,750	29,300	3.7
Aircraft	23,810	59,300	4.4	29,000	72,200	9.2
Industry	52,680	131,200	9.7	41,600	103,600	13.2
Sub-Total	95,760	238,500	17.6	87,500	217,900	27.7
Automotive (2)		1,114,500	82.4		568,200	72.3
Total		1,353,000	100		786,100	100

(1) Estimates in tons per year supplied by the Maryland State Bureau of Air Quality Control; converted to kg/day assuming 365-day operations.

(2) GCA estimates based on average weekday traffic.

Table II-11

HYDROCARBON EMISSIONS

Source Category	1970 tons/year	1970 kg/day	1970 %	1977 tons/year	1977 kg/day	1977 %
Non-Automotive(1)						
Power Plants	1,600	3,980	1.2	1,850	4,606	2.4
Refuse Disposal	755	1,880	0.6	300	747	0.4
Space Heating	940	2,340	0.7	1,070	2,664	1.4
Shipping, etc.(2)	1,869	4,660	1.4	2,136	5,318	2.8
Aircraft	8,450	21,040	6.3	2,900	7,221	3.8
Solvent Usage	24,900	62,000	18.7	11,200	27,887	14.8
Gasoline Distribution	15,575	38,790	11.7	15,000	37,350	19.8
Other Industry	2,000	4,980	1.5	2,300	5,727	3.0
Misc. Gasoline Use	3,925	9,770	2.9	4,470	11,130	5.9
Sub-Total	60,014	149,440	45.0	41,226	102,650	54.3
Automotive(3)		182,290	55.0		86,500	45.7
Total		331,730	100.0		189,150	100.0

(1) Tons/year supplied by Maryland State BAQC; converted to kg/day assuming 365 day operation.

(2) Figured as 60% of BAQC figure of same label to exclude diesel trucks and buses.

(3) GCA estimates based on average weekday traffic.

according to their actual location, and then assumed to be distributed uniformly within the area in the process of calculating emissions densities, as indicated in Table II-12. Specific District assignments were made for CO emissions from three sources: The Bethlehem Steel Sparrows Point facility, Friendship Airport, and the Glidden-Durkee facility near Curtis Bay. These sources account for nearly two-thirds of the regional total of non-vehicular emissions; they produced over 11 percent of the total regional CO emissions in 1970, and it is estimated that they will amount to over 15 percent of the total in 1977.

The major non-vehicular sources are large enough to be a significant portion of the CO problem in the area where their influence is felt; since high 8-hour CO levels occur at times of minimum meteorological dispersion, this is apt to be a fairly local small local area. Since it is likely that these problems can be better defined by special monitoring, etc., than through the empirical emission density-air quality methodology herein, they are not dealt with further here, except to note that the airport, while not a vehicular source in the sense of the present effort, isn't a stationary source in the sense that the State can deal with it as such, so that its problem potential may warrent note by EPA.

The non-vehicular hydrocarbon emissions, like the emissions from motor vehicles, were not distributed, but were treated in regional aggregate, because of the long-time and broad-area nature of the oxidant-formation mechanisms. The non-vehicular hydrocarbon emissions, however, pre-

TABLE II-12

NON-VEHICULAR CARBON MONOXIDE EMISSIONS DISTRIBUTION BY ANALYSIS AREA

(Emissions in kg/day[a])

	1970	1977	Change
Major Point Sources:			
Bethlehem Steel	73,500	36,750	-50%
Friendship Airport	59,300	72,200	+22%
Glidden-Durkee	19,900	9,950	-50%
Sub-total	152,700	118,900	-22%
Distributed Sources:			
Central Area	1,870	2,160	+16%
Fringe Area	10,180	11,740	+15%
Suburban Area	73,750	85,100	+15%
Sub-total	85,800	99,000	+15%
Total	238,500	217,900	- 9%

(a) Estimates in tons per year supplied by BAQC; converted to kg/day assuming 365-day operation.

sent a complication in another area. They are largely from widely-dispersed, small, retail gasoline and solvent-use sources, and as such are quite difficult to control. Because they represent a quite sizable part of the total, this relative inability to control the non-vehicular sources becomes a crucial factor in determining whether the standard can be met at all, let alone by the target date. Given this critical situation, it is inappropriate to maintain the crude assumption that all sources are uniformly distributed throughout the day, which assumption is implicit in using either annual or daily emission estimates.

To improve on this situation, the staff of the Maryland BAQC has devised a method of making emission estimates appropriate to the 6-9 a.m. time period of the hydrocarbon standard. This is done by applying to each of the various categories of emissions a factor representing the portion of the emissions from that type source that occur during the 6-9 a.m. period in the summer. Table II-13 summarizes these estimates; the second column lists the morning peak factors used, and the balance of the table results from applying these factors to the data of Table II-11.

E. EMISSION-AIR QUALITY RELATIONSHIP

While the relationship between motor vehicles and their emissions is a function of the automobiles themselves, subject to controlled engineering research, the relationship between the emissions and the ambient levels they produce is a function of meteorology, and must be determined empirically in each geographical area. Involved in making this determina-

TABLE II- 13

MORNING PEAK HYDROCARBON EMISSIONS

Source Category	Morning Peak Factor	1970 Morning Peak kg	1970 Morning Peak %	1977 Morning Peak kg	1977 Morning Peak %
Non-Automotive (1)					
Power Plants	1/8	498	0.8	576	1.9
Refuse Disposal	1/8	235	0.4	93	0.3
Space Heating	0	0	0.0	0	0.0
Shipping, Etc. (2)	1/8	583	1.0	665	2.2
Aircraft	1/8	2,630	4.5	903	3.0
Solvent Usage	1/12	5,168	8.8	2,324	7.7
Gasoline Distribution	1/12	3,233	5.5	3,113	10.2
Other Industry	1/8	623	1.1	716	2.4
Misc. Gasoline Use	1/32	305	0.5	348	1.1
Sub-Total		13,275	22.6	8,738	28.8
Automotive (3)	1/4	45,575	77.4	21,622	71.2
		58,850	100.0	30,360	100.0

(1) Tons/year supplied by Maryland State BAQC; converted to kg/day assuming 365-day operation.

(2) Figured as 60% of BAQC figure of same label to exclude diesel trucks & buses.

(3) GCA estimates based on average weekday traffic.

tion is the question of what type of model - proportional, full diffusion, or something intermediate - should be used to relate emission levels and air quality levels. Obviously, since at least for CO, data exists to define for us the geographical pattern of air quality levels, any required emission reduction should rationally be sought in those areas where the ambient pollutant levels are too high. This requirement eliminates the simplest possible choice, a proportional or rollback model based on a single maximum air quality value and the total emissions in the entire region.

The most complex possible choice would have been a full diffusion model, possibly with empirical sub-models to account for the effect of sensor location and to calculate the requisite inputs. For purposes of this study, the use of any such model had to be rejected on grounds of time and cost, thus leaving the choice among various forms of proportional modeling in some smaller areas. These models could be either based on emissions from all the Districts in the region, with the different porportionality constants being determined by diffusion techniques, or based on single areas of one size or another about the sites, with simple linear proportionality constants.

In brief summary, the method chosen for CO projections was porportional modelling in the three relatively homogeneous analysis areas, with one uniform proportionality constant for the three, to be determined from all the available data. The more complicated diffusion-allocated rollback possibilities, such as in de Nevers 1972, were not chosen because the meteorological presumptions of such methods do not agree with the known meteorological conditions at the times high CO levels typically occur.

For similar reasons, the choice for use with oxidants was proportional modeling on the single area defined by the Baltimore Metropolitan Area Transportation Study; the difference in the size of the areas chosen for the two pollutants reflects the different meteorological situations in which each normally reaches its maximum levels.

More specifically, the carbon monoxide methodology assumes that any measure of air quality would be proportional to the emission density at the point in question, the proportionality constant being simply the ratio of emissions to ambient concentrations, called "e/c ratio" for brevity. Once determined for an urban area, the e/c ratio can be applied to estimate the air quality associated with any emission density, or vice versa; in particular, it can be used to establish the "permitted emission density" associated with an air quality standard, in the present case, the 8-hour carbon monoxide standard of 9 ppm. The principal question in applying this projection procedure relates to choosing the areas within which to aggregate emission estimates into a single emission density figure, since various choices produce various results. It should be noted that if the entire study area is considered one area for this purpose, as with hydrocarbons, the procedure would be equivalent to a simple rollback of the region-wide emissions total.

While in the present study the BMATS Districts would seem a natural choice for aggregation areas, study of the Koppelman emission estimates led to the conclusion that they were not really valid at the District level, especially in the smaller center-city Districts where interest centers. Thus the BMATS Districts were aggregated into three "analysis areas," as described previously, and the density calculations for carbon monoxide were made for these areas, as presented in Table II-14. The analysis areas were defined in consultation with the Air Quality Task Force, and of course are designed to ease the considerations of the different types of strategies that might be applicable in the different portions of the urban area.

A similar but distinct question of choosing geographical areas arises in the actual determination of the e/c ratio. Because the ratio should in theory be a function of meteorological conditions primarily, it should remain essentially constant over an urban area; thus it was determined to utilize all the available data to provide one single ratio for use in all three analysis areas, using the 1970 emissions estimates and the measured air quality data to provide an e/c ratio at each air quality monitoring site. Even so, the area considered in aggregating the emission density around the station can affect the ratio at that site somewhat, and so can have some effect on the overall combined e/c ratio. Generally, in the various city studies, the immediate data reporting zone has been used, and this was also done in Baltimore, using the appropriate BMATS district. In several cases among the smaller Districts, however, it was necessary to include adjacent ones also, often because the site was quite near the District boundary. These aggregations were made in close consultation with the BAQC staff and the staff of EPA Region III.

TABLE II-14
CO EMISSION DENSITIES BY ANALYSIS AREA

	Emissions (kg/day)		Density (kg/day/mi^2)		Change (percent)
	1970	1977	1970	1977	
Central Area (10.73 mi^2)					
Motor Vehicle	108,450	50,085	10,107	4,668	-54
Stationary	1,870	2,144	174	200	+15
Total	110,320	52,229	10,281	4,868	
Urban Fringe (163.6 mi^2)					
Motor Vehicle	609,393	283,778	3,725	1,735	-53
Stationary[a]	10,174	11,665	62	71	+14
Total	619,567	295,443	3,787	1,806	
Suburban Area[b] (602.9 mi^2)					
Motor Vehicle	396,695	234,333	658	389	-41
Stationary[a]	73,736	84,546	122	140	+15
Total	470,431	318,879	780	529	

(a) Distributed stationary sources only.

(b) Calculated by difference - see note, Table II-9.

Developed in this way, the constant of proportionality, the "e/c Ratio," should be essentially constant over a geographic region, and hence over any set of sampling sites. Theoretically, the only differences among sites would be the slight differences one might expect in the meteorology over an area, which in the Baltimore area are believed to be slight.

In practice, however, the air quality monitoring sites cannot be presumed to represent precisely the average air quality over an area the size of even a small BMATS District, certainly not in the same sense that the average emission density does. Rather it would be a measure of the average air quality in an immediate neighborhood perhaps a few hundred meters in scale, with the results depending on whether the location is at a point with air quality higher or lower than the average over the area of interest. Thus one expects a certain amount of variability among the ratios from various sites.

While it isn't, of course, possible to be rigorous, general knowledge about urbanization leads one to conclude that in the central core of a city, this effect would likely be a lowering effect on the air quality there,as monitoring sites in the densest portion of the city are quite scarce by virtue of the very density they seek to reflect. On the other hand, suburban sites might be expected to give relatively high air quality values, because they must, of convenience if not of necessity, be located in the developed portion of the area, near human activity, as opposed to being located in the largely undeveloped portions of land in such areas.

There is very little that can be done to control this station-siting effect. Other than attempting to minimize it in choosing neighborhoods for sites, the only other approach, as is the case with many things, is to gather enough data that the effect can be averaged out.

In the case of Baltimore, there are seven independent estimates of this effect available in the observed values of the "e/c ratio" at the seven monitoring sites with valid data; if the results seem consistent with the theory as outlined, seven should be enough data points to average out the siting effect and give a reasonable estimate of the true value of the ratio.

The observed values of the "e/c ratio" actually determined, in Table II-15, vary a great deal, more so than was anticipated in advance. They do in fact, however, vary in a manner consistent with the previous discussion; the site closest to the city center yields a high value of the ratio (corresponding to relatively low air quality), and the suburban sites yield low ratios (high air quality), with the appropriate gradation between. The extreme lowest observed ratio, 78 kg/mi^2/ppm at the Riviera Beach site (#12), differs from the mean of the remainder by a factor of over 4; it was excluded as an outlier. That site lies in the most urbanized corner of a very large District, and hence represents an extreme example of the effect of aggregation. The average ratio, excluding Site 12, was 342 kg/day/mi^2 per ppm.

F. PROJECTED 1977 AIR QUALITY LEVELS

Having determined a uniform e/c ratio for CO, the 1977 air quality levels can be projected by applying the ratio to projected 1977 emission

TABLE II-15

EMISSION-CONCENTRATION RATIOS

Monitoring Station	BMATS Districts	Area mi^2	Vehicular	Stationary	Total	Maximum 8-hr CO (ppm)	e/c Ratio (kg/mi^2/day per ppm)
11	16	4.98	3,021	62	3,083	9.9	311
12	17	35.5	483	62	545	7.0	78
13	14	14.7	2,547	62	2,609	13.6	192
21	54,57	17.4	2,406	101	2,507	14.1	178
31	11,70,71 72,74	7.55	6,153	78	6,231	20.6	302
33	12,20,21	6.71	6,078	98	6,176	15.6	306
34	50,60	2.99	10,818	174	10,992	16.4	670

densities; and the problem can be described by comparing the projected CO levels to the standard. Alternatively, the ratio can be applied to the standard to produce the "permitted emission density", and this can be compared to the projected emission density. Similar approaches provide similar results for oxidants as a function of hydrocarbon emissions, except that the relationship is not strictly linear, but is presumed to follow Appendix J, Federal Register 36:158:II:15502, 14 August 1971.

Table II-16 projects 1977 carbon monoxide levels in the three analysis areas. The upper portion summarizes the emission density calculations, both in density units and as percentages of the 1970 density. In the Suburban Area, the existing 780 kg/day/mi^2 is well below the 3078 that is equivalent to the 8-hour standard. In the Fringe Area, a density reduction of 18.7 percent is required to meet the standard, and this is easily accomplished by the federal motor vehicle control program. In the Central Area, however, further transportation controls will be required. The emission density must be reduced by 70.1 percent, from 10,281 to 3,078 kg/day/mi^2, in order to meet the standard. but the vehicle control program reduces total emissions by only 52.9 percent. Including a small increase in stationary source emissions, the projected 1977 emission density is 4,868 kg/day/mi^2. This requires a further reduction, which will need to come from transportation controls, of 1,790 kg/day/mi^2, which is 17.4 percent of the 1970 level, or 36.8 percent of the projected 1977 emission density.

The lower portion of Table II-16 summarizes these results in terms of expected ambient carbon monoxide levels. It must be emphasized that

TABLE II-16

CALCULATIONS FOR CARBON MONOXIDE PROJECTIONS

Emission Density Calculations	CO-Central Area		CO-Fringe Area		CO-Suburban Area	
	Emission Density (kg/day/mi^2)	Percent of 1970	Emission Density (kg/day/mi^2)	Percent of 1970	Emission Density (kg/day/mi^2)	Percent of 1970
1970 Estimate	10,281	100.0	3,787	100.0	780	100.0
Change from Motor Vehicle Sources	- 5,439	- 52.9	- 1,990	- 52.5	- 269	- 34.5
Change from Stationary Sources	+ 26	+ 0.2	+ 9	+ 0.2	+ 18	+ 2.3
1977 Without Control Strategies	4,868	47.3	1,806	47.7	529	67.8
Permitted (8-hr Standard)	3,078	29.9	3,078	81.3	3,078	394.6
Further Reduction Required	1,790	17.4	0	0.0	0	0.0
Virtual Air Quality[(a)] (ppm)						
1970	30.1		11.1		2.3	
1977 Without Strategies	14.2		5.6		2.2	
1977 With Standard Met	9.0		9.0		9.0	

(a) Calculated by dividing above by e/c = 342 these are virtual concentrations; since they are calculated from the average emission density in the analysis area, they represent the average air quality over the area, rather than being uniquely identified with a specific site. The expected levels in the Fringe and Suburban areas in 1977, after transportation controls have been applied, are simply entered as being below the standard because it is not known whether they might be raised slightly as a by-product of controls designed to reduce levels in the Central Area. The precise effect, if any, would depend on the control measures selected, but it is extremely unlikely that they would even approach the 9 ppm standard.

Table II-17 presents the calculations for projections of 1977 hydrocarbon emissions and ambient oxidant levels, with the entire BMATS area considered a single area, with parallel calculations based on the two different assumptions about emission inventories discussed in Subsection II D. In either case, the combined vehicular control program and stationary source control fall far short of the 60 percent reduction needed to meet the standard. The further-required 26.0 and 20.6 percent of 1970 emissions represent 45.6 and 40.0 percent of expected 1977 emissions, respectively.

TABLE II-17

CALCULATIONS FOR OXIDANT-HYDROCARBON PROJECTIONS

Maximum 1-hour oxidant measurement 0.21 ppm

Requisite reduction in hydrocarbon emissions(a) 69%

	Summary of Emission Projections			
	Average Day		Summer a.m. Peak	
	kg/day	% of 1970	kg/3 hrs	% of 1970
1970 Total estimate	331,730	100.0	58,850	100.0
Change from Motor Vehicles	-95,790	-28.9	-23,953	-40.7
Change from Stationary Sources	-46,790	-14.1	- 4,537	- 7.7
1977 without strategies	189,150	57.0	30,360	51.6
Required to meet standard(b)	102,836	31.0	18,244	31.0
Further reduction required	86,314	26.0	12,116	20.6

(a) From Federal Register, op. cit.

(b) 1970 total less 69 percent

III. EVALUATION OF POSSIBLE CONTROL STRATEGIES

In order to meet contractual timetable requirements, it was necessary to conduct most of the evaluation and analysis of alternative strategies and their impacts prior to detailed definition of the problem. During the early portion of the study period, it was presumed, on the basis of the existing implementation plan, that the air quality problem in Baltimore would be primarily a relatively localized carbon monoxide problem, and the preliminary investigation of alternative control strategies was directed toward meeting that problem. As the new AIRMON data was processed, however, it subsequently became apparent that there would be a region-wide photochemical oxidant problem of considerable magnitude. This would require a different set of solutions.

This section of the report will describe the proposed strategies, present a technical evaluation and estimate of potential emission rate or VMT reduction for each of the analysis areas, and summarize the findings. Because of the constraints just discussed, however, the focus on the recommended program of strategies is not as thorough as originally planned.

A. IDENTIFICATION AND PRELIMINARY EVALUATION

A set of preliminary alternatives was established through the combined efforts of the consultants and the members of the Air Quality Task Force. The set consisted of the following alternatives:

Strategies to Reduce Emission Rate

- Vehicle Retrofit
- Inspection and Maintenance
- Gaseous Fuel Conversion
- Traffic Flow Improvements

Strategies to Reduce Vehicle Miles of Travel

- Transit Service Improvements
  - Reduced Transit Fares
  - Reserved Lanes or Dedicated Streets for Buses
- Car Pools
- Motor Vehicle Use Restraints
  - Increased Parking Charges
  - More Fringe Parking
  - Elimination of On-Street Parking During Off-Peak Hours
- Vehicle Free Zones in CBD
- Staggered Work Hours
- Four-Day, 40-Hour Work Week
- Increased Fuel Tax

The preliminary evaluation as shown in Table III-1 was presented to the Air Quality Task Force and Table III-1 has been modified to reflect their comments. The table was necessarily brief to present a basis for discussion. The "Status" category refers to the proposed method of quantifying. Each "Element" was reviewed independently for further evaluation and possible incorporation in the proposed program package.

TABLE III-1 PRELIMINARY EVALUATION OF TRANSPORTATION CONTROLS

1. Element - Vehicle Retrofit

Description

Provide anti-pollution devices to pre-1968 vehicles, mandatory, or at time of sale; controlled vehicles if necessary to meet standards

Status

Quantify - determine net difference in VMT pollutants caused by older vehicles as a baseline check

Feasibility

Legal: Requires state enabling legislation by 1974 to implement
Economic: Private - costly if individual bears total burden; state or local funding program necessary
Institutional: Local enforcement and compliance machinery required
Political: Affects low-income people
Technical: Can be bypassed; availability of effective equipment and manpower

Impacts

Air Quality: Pre-1968 vehicles--5-25%, controlled vehicles--8-30% pollutant reduction per vehicle (CO and HC)
Transportation: No effect on mode choice or travel patterns

Comments

Low Feasibility

2. Element - Inspection and Maintenance

Description

Incorporate anti-pollution device inspection and emission test with (proposed) safety inspection

Status

Quantify, using model; modify emission curves to assume all vehicles meet standards without deterioration

Feasibility

Legal: Need vehicle safety inspection law plus emission law
Economic: Capital equipment, training, maintenance program Estimate $40 million capital costs, plus $7-$8 million annual operating costs (including safety program)

(TABLE III-1 CONTINUED)

Institutional: Uncertainties expressed by officials; private or public stations. Jurisdictional problems in implementation phase

Political: If private inspection stations, subject to political favors promoted by auto manufacturers

Technical: NO_x tradeoff - Frequency of inspection required for effectiveness - Mandatory maintenance required - Rejection rate

Impacts

Air Quality: 10-20% per vehicle (CO and HC)

Transportation: No effect on mode choice or travel patterns

Comments

Low Feasibility

3. Element - Gaseous Fuel Conversion

Description

Convert Fleet vehicles to gaseous fuel

Status

BAQC studying taxi and other fleet conversions - Report November 1 - no VMT test

Feasibility

Legal: Would be discriminatory if required for fleets. Law required to effectuate

Economic: Conversion costs approximately $300 to $400 per vehicle

Institutional: Selection process of candidate vehicles impacts private sector

Political: Voluntary or mandatory?

Technical: Availability of fuel supply is critical constraint Requires proximity to compressor-vehicles cannot use tunnels

Impacts

Air Quality: Less than 15% (CO and HC) per vehicle

Comments

Low feasibility

(TABLE III-1 CONTINUED)

4. Element - Traffic Flow Improvements

Description

Improve flow rate to alleviate idle mode and generally increase speed on arterials

Status

Traffic flow in Baltimore is presently well-planned and administered-new traffic signal system will improve flow further by 1977 - evaluate traffic signal improvements, then re-examine TOPICS type improvement

Feasibility

Legal: No problems with regard to signal system
Economic: Signal system already budgeted
Political: No one adversely affected
Institutional: City controls traffic operations
Technical: Little room for improvement after new signal system - probably 5 percent improvement on arterial systems

Impacts

Transportation: Encourages more travel on roads that become less congested

5. Element - Transit Service Improvements

Description

Service improvements - speed, frequency, schedules, etc., which will encourage transit riding

Status

Service improvements not quantified separately

Feasibility

Economic: UMTA capital grant; who pays increased operating costs not covered by increased revenue?
Institutional: Would require significant policy shifts

Impacts

Transportation: Minimal shift in auto usage expected if based on transit service improvements only

Comments

Consider in combination with lower fares, increased parking charges, fringe parking

(TABLE III-1 CONTINUED)

5.a Sub-Element - Reduced Transit Fares

Description
Reducing fares on buses will tend to increase transit riding

Status
Revise VMT based on estimated increase in transit riding

Feasibility
Legal: Can fares be subsidized?
Economic: Funding for fares; funding for new buses (UMTA)
Institutional: Consistent with MTA policy?
Political: A political plus, since it benefits low-income

Impacts
Transportation: Some shift in mode to transit expected

5.b. Sub-Element - Reserved lanes or Dedicated Streets for Buses

Description
Currently have reserved lanes in peak-hour on major streets

Status
Estimate traffic flow improvement - little increase in transit usage expected

Feasibility
Economic: Signing and enforcement costs
Institutional: Enforcement of reserved lanes
Technical: Need to maintain headways without bunching - Consider dedicated street for access

Impacts
Transportation: Could improve flow on certain streets, possibility of platooning

Comment
Greater effectiveness if employed in conjunction with fringe parking lots

6. Element - Car Pools

Description
Encourage pooling in CBD by economic, social, or political means; reserved lanes for car pools on expressways and city streets

(TABLE III-I CONTINUED)

Status
Decrease in VMT can be estimated from increased car occupancy changes

Feasibility
Legal: Enforcement problems
Economic: Cost of plan and enforcement; cost of construction, implementation and enforcement
Institutional: Possibility of developing pooling information systems; militates against staggered hours, etc.
Social: Constraints to force pooling may be unacceptable
Technical: Information system highly complex; Los Angeles test not promising

Impacts
Transportation: Reduce VMT

Comments:
Could be effective if in combination with parking charge increase

7. Element - Motor Vehicle Use Restraints
7.a. Sub-Element - Increased Parking Charges

Description
Concomitant with improved bus service, reduced bus fares and/or car pooling efforts

Status
Existing tax could be increased enough to divert to transit; revised VMT can be estimated

Feasibility
Legal: Research required; enforcement
Economic: Reduced revenues concern of bond-holders; city is competing with shopping centers with free parking
Institutional: Use of increased revenue - Possibility of public lots and garages reverting to private use; city does not want to penalize downtown parkers
Social: Unpopularity of increased taxes; regressive; impacts low income; impact on CBD

Impacts
Transportation: Will cause shift of VMT to other areas

Comments
Feasible only for Commuters

(TABLE III-1 CONTINUED)

7.c. Sub-Element - Eliminate On-Street Parking during Off-Peak

Feasibility
Legal: Enforcement of parking limits is only 75% effective presently
Social: Off-peak elimination cannot be justified

Impacts
Air Quality: Negligible impact on air quality

Comments
Low Feasibility and effect

8. Element - Vehicle Free Zones(s) in CBD

Description
Eliminate traffic (possibly allow buses) in restricted areas

Status
Not feasible for total area; may be quantified for "hot spots"

Feasibility
Legal: Presently in litigation for suggested street closing on Lexington; denial of access
Economic: Cost of providing adequate parking on fringe
Institutional: Deliveries; transit; auto-oriented businesses
Social: Problems may only be shifted; business may move out of city
Technical: Adequacy of other streets

Impact
Air Quality: Would improve air quality in the restricted area, may reduce air quality on periphery or adjacent street

Comment
Effective only if necessary to alleviate "hot spots" problem.

9. Element - Staggered Work Hours

Description
Voluntary or mandatory staggering of start and quit work hours

Feasibility
Institutional: Probably relatively easy to develop in CBD; trend is in this direction; means of accomplishing
Impacts
Air Quality: Would not improve regional air quality problem
Transportation: This is a peak-shaving method presently practiced in Baltimore in some areas

(TABLE III-1 CONTINUED)

10. Element - Four Day, 40-Hour Work Week

Description
Tends to spread travel over the day (reducing peak concentrations) and reduce VMT on a given day

Feasibility
Legal: Overtime pay; restrictions on female hours per day
Institutional: Interface with public and other businesses
Technical: Militates against car pooling and increased transit usage

Comment
Could be instituted at large employment centers such as state offices or Social Security for most effectiveness

11. Element - Increased Fuel Tax or Impose Sales Tax

Description
Would require "significant" increase to be effective

Status
Can quantify small increases on macro basis

Feasibility
Legal: Would require legislation; enforcement difficult due to proximity to adjacent states
Economic: Revenues could be used for increasing transit service
Institutional: If statewide, would affect residents of non-impacted areas
Social: Regressive tax for low-income

Impacts
Transportation: Would reduce VMT if tax were high enough

Comment
Would function as road pricing mechanism, with revenues to be used for transit

B. STRATEGIES TO REDUCE EMISSION RATE

1. Inspection and Maintenance Program - An inspection and maintenance program would require periodic inspection and maintenance of emission control devices, as well as other auto components that determine the emission characteristics of a particular vehicle. In Baltimore, a reasonable approach would be to incorporate such a testing program into the proposed periodic motor vehicle safety inspection program.

The results of EPA studies on light duty vehicles indicate average initial reductions of 25 percent for hydrocarbons, 19 percent for carbon monoxide, and 0 percent for oxides of nitrogen using a loaded emissions test*. However, due to deterioration of parts related to emissions, control or deliberate disconnects of these parts, it may be expected that actual emissions reductions will be considerably less than the averages from the EPA test procedures. Although EPA tests were relevant only for 1971 vehicles, it may be assumed that similar results will occur for future model years. Lacking better data on deterioration factors, it has been assumed that linear deterioration to the emission level before maintenance will occur over the 12-month period between tests. As a result, the average effectiveness for annual inspection is estimated to be about one-half of the initial effectiveness, that is, average reductions of 12 percent for hydrocarbons, 10 percent for carbon monoxide, and 0 percent for oxides of nitrogen on a regional basis.

The overall effectiveness of the inspection and maintenance program will be influenced by many factors including the test procedure

* Environmental Protection Agency, "Requirements for Preparation, Adoption and Submittal of Implementation Plans," (Draft) October 26, 1972

(the original state plan was sized for idle mode test with a complete diagnostic test option at additional cost to the patron), the rejection rate, and enforcement. Regional reductions will also be affected by changes in VMT.

2. Retrofit of Uncontrolled Vehicles - The Environmental Protection Agency has provided estimates of the effectiveness of various retrofit measures in reducing emissions from light duty vehicles.* The measures discussed by EPA are divided into two sets. The first set consists of retrofit measures applicable to pre-controlled (i.e., pre-1968) vehicles, while the second set consists of measures applicable to controlled vehicles. Each measure has an associated average reduction per vehicle for hydrocarbons, carbon monoxide, and oxides of nitrogen, as reproduced in Table III-2.

In order to use these vehicle-related emission reductions, it was necessary to calculate the proportion of total emissions contributed by vehicles of various model years, based on the data in Table II-8. By using the effectiveness data and the model-year distribution in conjunction with the base emission factors and deterioration factors, it is possible to estimate the effect of a retrofit strategy on total light duty emissions. As an example, Table III-3 summarizes such calculations for hydrocarbons from light duty vehicles, for three levels of application of the most effective retrofit devices, oxidizing catalytic converters. The effectiveness data compiled by EPA is presented as reductions from an on-going, maintained, emission-base, i.e. after the reduction due to the

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* Environmental Protection Agency, Requirements for Preparation, Adoption and Submittal of Implementation Plans, " (Draft) October 26, 1972

TABLE III-2

EFFECTIVENESS OF RETROFITTED CONTROL DEVICES

Retrofit Option	Average Reduction per Vehicle		
Pre-1968 Vehicles:	HC	CO	NOx
Lean idle Air/Fuel Ratio Adjustment and Vacuum Spark Advance Disconnect	25%	9%	23%
Oxidizing Catalytic Converter and Vacuum Spark Advance Disconnect	68%	63%	48%
Air Bleed to Intake Manifold	21%	58%	0%
Exhaust Gas Recirculation and Vacuum Spark Advance Disconnect	12%	31%	48%
1968 and Later Vehicles:			
Oxidizing Catalytic Converter	50%	50%	0%
Exhaust Gas Recirculation	0%	0%	40%
Oxidizing Catalytic Converter and Exhaust Gas Recirculation	50%	50%	50%

Source: Environmental Protection Agency, "Requirements for Preparation, Adoption, and Submittal of Implementation Plans (Draft), October 26, 1972.

TABLE III-3

EFFECT OF VARIOUS RETROFIT PROGRAMS ON LIGHT-DUTY VEHICLE HYDROCARBON EMISSION RATES

	Percent of 1977 VMT	Percent of 1977 Emission	Hydrocarbon Emissions (% of 1977 Base)			
			-12% for Insp./Maint.	Oxidizing Calalytic 1971-74	Converter 1968-1974	Retrofit All Vehicles
≤ 1965	1.3	5.42	4.77	4.77	4.77	1.53
1966	0.7	2.89	2.54	2.54	2.54	0.81
1967	1.0	4.33	3.81	3.81	3.81	1.22
1968	2.3	5.42	4.77	4.77	2.39	2.39
1969	4.7	14.08	12.39	12.39	6.20	6.20
1970	5.0	12.64	11.12	11.12	5.56	5.56
1971	9.2	9.75	8.58	4.29	4.29	4.29
1972	7.8	9.75	8.58	4.29	4.29	4.29
1973	9.3	11.55	10.17	5.09	5.09	5.09
1974	10.1	12.27	10.80	5.40	5.40	5.40
1975	13.3	3.61	3.18	3.18	3.18	3.18
1976	21.7	5.05	4.44	4.44	4.44	4.44
1977	12.6	2.53	2.23	2.23	2.23	2.23
1978	1.0	0.71	0.62	0.62	0.62	0.62
	100.0	100.00	88.00	68.94	54.81	47.25
Change from previous column			(-12.00)	(-19.06)	(-14.13)	(-7.56)
Aggregate Change			-12.00	-31.06	-45.19	-52.75

necessary inspection-maintenance program. Thus the effect of an inspection-maintenance program, a 12 percent reduction in the case of hydrocarbons, is also included in the Table III-3 calculations.

By 1977 the contribution of pre-1968 vehicles will be relatively small; therefore, retrofit measures applied to pre-controlled vehicles will be relatively ineffective overall, and hence might be excluded from a retrofit program. Although significant emission reductions could be achieved by retrofitting all 1968 and after controlled vehicles with oxidizing catalytic converters, some of the 1968-1970 models may have operating problems with the unleaded gasoline required to maintain catalyst effectiveness. Since this would presumably increase enforcement difficulties, excluding these vehicles might also be a sensible option. Consequently, the effectiveness is determined for three possible variations of a retrofit program, based on which model year vehicles are included.

If the most effective retrofit devices are used on all vehicles, and an inspection-maintenance program is instituted, then the emissions from light duty vehicles would decrease by about 53 percent for carbon monoxide and 47 percent for hydrocarbons. In 1977, however, light duty gas vehicles, while accounting for 86 percent of the area-wide VMT, will account for much smaller portions of the motor vehicle emissions-- only 61 and 55 percent of the CO and hydrocarbon emissions respectively; the balance is largely from heavy duty gasoline vehicles, which are relatively uncontrolled (see Table II-9). In addition, it is presumed that the overall effectiveness will be reduced by at least 5 percent by the inclusion of emissions from non-retrofitted transient vehicles. Thus the overall reduction in area-wide hydrocarbon emission, say, would be only 27.3 percent of the motor vehicle portion, and a smaller proportion of the total emissions. Table III-4 summarizes these adjustments. Since the reductions in light duty vehicle emissions ultimately are seen to be insufficient, the effect of a minor program of retrofitting heavy duty vehicles was also calculated. Summarized in Table III-5, these calculations are based on reducing evaporative and crankcase emissions from pre-1973 trucks to the 0.8 gram/mile figure applicable to 1973 and later models; the result is a 6.8 percent reduction in heavy duty vehicle hydrocarbon emissions.

3. Conversion to Gaseous Fuels - The Bureau of Air Quality Control investigated the feasibility and effectiveness of fleet conversion to gaseous fuel. Due to the technological requirements of converting gasoline-powered vehicles to gaseous fuels such as liquified natural gas (LNG), liquified petroleum gas (LPG), or compressed natural gas (CNG) the most feasible approach was to consider conversion by fleet vehicles only. The relatively small range of travel distance provided by gaseous fuels severely restricts the mobility and flexibility of vehicles which use it. In addition, the costs of converting to gaseous fuel operation and the accessibility of supply stations necessarily limits the potential. The primary constraint is the relatively limited supply of these fuels in the Baltimore area. Thus, such operations are generally considered appropriate only for operators of large fleets of vehicles such as government, delivery or service trucks, and taxicabs. In addition, there is a restriction on the use of the Harbor Tunnel by vehicles carrying propane or other pressurized tanks.

TABLE III-4

EFFECT OF LIGHT-DUTY RETROFIT PROGRAMS ON ACTUAL MOTOR VEHICLE POPULATION

Retrofit Program		Reduction of Emissions from Single Light-Duty Vehicle (a)	Reduction of Emissions from Population of Light-Duty Vehicle (b)	Reduction of Emissions from Entire Motor Vehicle Population (c)
I & M only	HC	12.00% (d)	7.37%	4.01%
(Inspection & Maintenance)	CO	10.00%	5.27%	3.19%
I & M plus Retrofit	HC	31.06%	27.43%	14.92%
Model Years 1971-74	CO	32.63%	29.08%	17.59%
I & M plus Retrofit	HC	45.19%	42.31%	23.02%
Model Years 1968-74	CO	46.27%	43.44%	26.28%
I & M plus Retrofit	HC	52.75%	50.26%	27.34%
All Model Years	CO	52.92%	50.44%	30.52%

(a) From calculations as in Table III-3.

(b) Assumes regulation of only 95% of light-duty vehicles, to allow for transient vehicles; note this percentage assumes rigorous enforcement, and should be much lower if such enforcement is not provided.

(c) Light-duty vehicles emit 60.5% of total CO and 54.4% of total HC.

(d) Four significant digits are kept to preserve accuracy for subsequent calculations; if is not meant to imply the estimates are that precise.

TABLE III-5

EFFECT OF EVAPORATIVE AND CRANKCASE RETROFIT ON HEAVY-DUTY VEHICLES

					Emission Factors (gram/mile)					Effect of Retrofit	
Model Year	Vehicle Age in 1977	Registered Vehicles (a) (percent)	Average Mileage (1000's)	Weighted Travel (b) (percent)	Base Emission Factor	Deterioration	Evaporative & Crankcase	Total (c)	Weighted Emissions (grams/mile)	Emission Factor (d)	Weighted Emissions (grams/mi
1978	0	3.0	3.5	0.9	7.8	1.00	0.8	8.60	7.7	8.60	7.7
1977	1	10.8	11.7	10.8	7.8	1.24	0.8	10.47	113.1	10.47	113.1
1976	2	13.5	17.2	19.7	7.8	1.35	0.8	11.33	223.2	11.33	223.2
1975	3	10.7	15.8	14.4	7.8	1.41	0.8	11.80	169.9	11.80	169.9
1974	4	8.3	15.8	11.2	77.8	1.47	0.8	12.27	137.4	12.27	137.4
1973	5	8.1	13.0	9.0	15.0	1.53	0.8	23.75	213.8	23.75	213.8
1972	6	7.7	13.0	8.5	15.0	1.58	3.0	26.70	227.0	24.50	208.3
1971	7	6.4	11.0	6.0	15.0	1.63	3.0	27.45	164.7	25.25	151.5
1970	8	5.3	11.0	5.0	15.0	1.67	3.0	28.05	140.3	25.85	129.3
1969	9	4.2	9.0	3.2	19.0	1.00	3.0	22.00	70.4	19.80	63.4
1968	10	3.3	9.0	2.5	19.0	1.00	3.0	22.00	55.0	19.80	49.5
≤1967	≥11	18.7	5.5	8.8	19.0	1.00	8.2	27.20	239.4	19.80	174.2
		100.0		100.0					1761.9		1641.3 =

93.2% of
1761.9, or
6.8% reductio

(a) From Table II-8

(b) Product of 2 previous columns, normalized to 100%

(c) Base x Deterioration + Evap-Crkcase

(d) Base x Deterioration + 0.8 for all years

Emissions from vehicles converted to natural fuels have proved to be much lower than from the same vehicle operating on gasoline.* For many fleets which have converted, operating costs have declined.

The technological and political obstacles to mandatory conversion program, however, preclude consideration as a major strategy in the Baltimore region and the relative impact would not be sufficient to warrant such an approach.

Therefore, the best approach appears to be a voluntary program for gaseous fuel conversion in the Baltimore area.

4. Traffic Flow Improvements - The application of traffic operations improvements on an area-wide basis would be expected to yield significant improvements in air quality. By decreasing the amount of time spent idling and by increasing operating speeds on the street system, the average emission rates could be reduced.

The type of improvements suggested would not include construction of major new facilities, but rather the application of TOPICS-type improvements, including sophisticated signal control, parking restrictions, lane widening, turn-lane additions, and other minor redesign and channelization requiring a minimum of new right-of-way.

Due to the fact that the Federal TOPICS program has been in existence only a few years, before-and-after studies are not readily available. A survey of selected TOPICS reports found predicted average speed increases ranging between 15 percent and 36 percent. In Gateshead, England, where a before-and-after study of a traffic management plan was completed, it was found that average speed in the cordon area increased from 11.9 miles per hour to 16.3 miles per hour, a 37 percent increase.*

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* U.S. General Services Administration, Pollution Reduction with Cost Savings. No date.

It is generally recognized that traffic flow in Baltimore is presently well planned. Furthermore, bids have been solicited for a digitized computer traffic signal control system which will be directly responsible to traffic conditions. This system will be operational prior to 1977. The backup study for this signal system predicted that a 10 percent improvement in traffic operations would be realized.**

It is conservatively estimated that a comprehensive traffic flow improvement program could yield speed increases of 5 percent on expressways and local streets, 15 percent on arterials, and an overall average of 10 percent.

Examination of the emission factor indicates the great importance of average speed as a determinant of motor vehicle emissions. In particular, at low speeds, such as are prevalent in the central area of Baltimore, a relatively small increase in speed could yield a very significant decrease in emission rates.

It is suggested that the speed increases estimated above be fully evaluated by inputting them into the emissions model on a district basis.

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* Leanard, J.H., Benefits from TOPICS-Type Improvements. Civil Engineering ASCE, 41:2, pp. 62-66, February 1971.

** Peat, Marwick, Livingston & Co., Traffic Signal System Study, Feb. 1969.

A deleterious side effect of this type of improvement is the possible long-term stimulus to increase trip lengths and to induce additional traffic. Over the short term, however, these effects should be negligible.

An electronic surveillance and control technique will be installed experimentally on the Jones Falls Expressway (I-83). Installation of conduits should begin in early 1973. Since there are no parallel routes to which vehicles may be diverted through ramp metering or electronic messages, an information-only technique will be employed, primarily for safety purposes. Detection devices will be placed every 0.2 mile of the six-mile length of expressway in Baltimore City and information on traffic status will be sent from the detectors to a computer. The computer will assess the situation and transmit information to signs placed at one-mile intervals. These signs will convey information to motorists about the conditions ahead on the roadway. It is not expected that this system will have a significant impact on speeds due to the absence of parallel roads for diversion. It is planned that all sections of the 3-A System which are constructed will have conduits built in for surveillance and monitoring systems if needed.

C. STRATEGIES TO REDUCE VEHICLE USAGE

1. Transit Service Improvements

Considerable attention has been directed to the potential for decreasing auto usage by making improvements to operating characteristics of transit systems. This aspect of diverting auto trip makers was investigated for Baltimore based on a previous mdal split study.*

This study indicated that the disutility associated with access (out of vehicle) time was slightly greater than twice the disutility associated with line haul time. It was thus possible to evaluate a two-minute line haul time reduction and a one-minute access time reduction simultaneously.

The effect of such a reduction was evaluated with the modal split study which indicated percent transit of total person trips as a function of income group, parking cost, a weighted measure of the travel time difference between auto and transit, and trip purpose.

The mean travel time difference for each trip purpose was used as a point of departure for shifting to reflect a modified travel time difference induced by transit service improvements. The shift in modal split was determined on a disaggregate basis for each income level. The measures obtained were weighted by the number of families in each group to obtain a weighted average of peak period modal split for each trip purpose. By weighting the trip purposes according totheir relative frequency of occurrence, it was possible to derive changes in modal split on a regional basis. A distinction was made between central area effects which were measured using modal split curves corresponding to a \$.09 - \$.29 per hour range of parking charges and urban fringe-suburban effects which were measured using curves corresponding to zero parking charge.

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* Alan M. Voorhees & Associates, Inc., A Report on Mode Choice Analysis for the Baltimore Region, prepared for the Baltimore Regional Planning Council, 1969.

Based on this methodology, it was found that in the central area a two-minute reduction in line haul time or a one-minute reduction in access time could raise peak period modal split from a current 47 percent to 49 percent. The same policy would increase peak period modal split in fringe and suburban areas from a current 19 percent to 20 percent. It is estimated that these shifts would create a VMT reduction of 3 percent in the central area and 2 percent in the urban fringe and suburbs.

MTA transit planning is presently being reviewed under an Urban Mass Transportation Administration technical study grant. The study report had not been released at the time of this study, but it is understood there will be recommendations for transit service improvements and downtown distribution systems.

Reduced Transit Fares -- Reducing transit fares was seen as a potential means of increasing transit ridership and thereby reducing auto travel. One study conducted for the U.S. Department of Transportation* indicated that transit demand is relatively inelastic with respect to fare increases. It was estimated that if fares were completely eliminated in Boston, a four percent area-wide reduction in auto emissions would result.

Notwithstanding the results of the Boston study, the possibility of reducing transit fares was examined in Baltimore with two alternative assumptions: (1) free transit, and (2) reducing transit fares by 15 cents. The potential for reducing VMT through these measures was found to be quite significant. The impact on transit usage of a free transit system yielded anticipated VMT reductions in the 13-14 percent range, over the whole system.

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* Domencich, T.A. and G. Kraft, Free Transit, D.C. Heath Co., Lexington, Mass., 1970.

Due to the poor implementation probability of a totally subsidized transit system, consideration was also given to the possiblity of decreasing transit fares by 15 cents. Anticipated VMT reductions amounted to seven percent in the central area and four percent in the urban fringe and suburban areas.

Changing Transit Fares - Current Mass Transit Administration (MTA) fare policies in Baltimore City are summarized below:

Base fare	30 cents
Transfer charge	5 cents
Zone charge	10 cents
Children & students	15 cents
Senior citizens	15 cents

The effect of a free transit system was evaluated primarily using the recent Baltimore mode choice study,* previously mentioned. To evaluate free transit, it was necessary to consider a conversion from fare reduction to an equivalent travel time savings. It was assumed that average cost reductions of a free transit system would amount to 35 cents, excepting the lowest income group (assumed to consist largely of persons with reduced fare privileges) were a 20-cent average reduction was assumed. It was further assumed that commuting time was valued at one-third of the family hourly income rate.

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* Alan M. Voorhees & Associates, A Report on Mode Choice for the Baltimore Region, prepared for the Baltimore Regional Planning Council, 1969.

The Baltimore modal split study included mean travel time differences for each trip purpose. In each case, this was assumed to be the point of origin from which free transit was shifted. The fare savings on a disaggregate basis by income group and the relationships developed in the study were used to measure the shift in modal split effected. The measurements thus obtained for each income group were weighted according to the number of families in each group to obtain a weighted average of peak period modal split for each trip purpose. By weighting these figures according to the relative trip-making frequency of each trip purpose, it was possible to estimate the total shift in modal split for all trip purposes.

In applying the modal split study to the central area, the set of curves with parking charges in the \$.09 - \$.29 per hour range were used. Using the foregoing methodology, base condition modal split into the central area was estimated at 47 percent for the peak period. This estimate compares quite favorably with the 39 percent modal split developed in the BMATS study for a 24-hour period. Assuming free transit service, peak period modal split was estimated at 54 percent.

In applying the methodology to non-central areas, the modal split curves assumed no parking charges were used. This analysis indicated a current peak period modal split of 19 percent with an increase to 30 percent under a free transit scheme.

The potential impact on VMT of decreasing transit fares 15 cents was evaluated using an identical methodology to that employed for free transit. The cost reduction was converted to an equivalent time savings and the modal split results utilized. Based on this technique, the anticipated increase in modal split from 47 to 51 percent in the central area and from 19 to 22 percent in the urban fringe and suburbs would yield a 7 percent VMT reduction in the central area and a 4 percent VMT reduction in the fringe and suburban areas.

The feasibility of transit fare reductions is dependent primarily on the legal implications of subsidizing the system, especially under MTA requirements to meet costs "as far as practicable" from the fare box. Politically, these alternatives are attractive, since they would particularly tend to benefit low income groups.

The following table summarizes the results of implementing a free transit policy in Baltimore:

TABLE III-6 EFFECT OF CHANGING TRANSIT FARES ON VMT

	Present Modal Split % Transit	Free Transit Modal Split % Transit	Free Transit Change in VMT	15 Cent Reduction Modal Split % Transit	15 Cent Reduction Change in VMT
Central Area	47	54	-13%	51	-7%
Urban Fringe	19	30	-14%	22	-4%
Suburbs	19	30	-14%	22	-4%

Reserved Lanes or Dedicated Streets for Buses - This potential control strategy should perhaps be considered a sub-element of transit service improvements. The ultimate impact on transit usage of reserving lanes or streets for buses is achieved through its effectiveness in reducing waiting time or line haul travel time. The analysis performed for transit improvements is therefore valid here; that is, if reserving lanes or streets could reduce the average wait by one minute or reduce the average travel time by two minutes, VMT could be reduced by an estimated 3 percent in the central area and by 2 percent in the urban fringe and suburbs.

Transit operations could be improved somewhat by strict enforcement of existing reserved lanes in the downtown area. There are about 14 miles of reserved bus lanes in downtown Baltimore. MTA is presently considering some additional bus lanes in the east-west direction.

Although the application of this element of a control strategy does not appear extremely effective in itself, the adoption of a set of policies that would otherwise significantly increase transit usage may require the institution of short segments of reserved street operations on those few downtown streets which serve as foci of the transit system.

Reserved lanes for express bus service from fringe parking areas would be essential to the successful operation of such fringe parking facilities.

2. Motor Vehicle Use Restraints

Downtown Parking Charges - The potential reduction in VMT through increasing downtown parking charges was evaluated using the modal split study together with the Downtown Parking Study.* Again, the base condition was assumed to be represented by the set of curves corresponding to parking charges in the $.09 - $.29 per hour range. The change in modal split induced by raising parking charges was measured using the set of curves corresponding to parking charges greater than $.30 per hour. Contributions of each income stratum were weighted according to the number of families in that stratum. Similarly, weights were applied to each trip purpose to derive overall effects. Applying this methodology indicated that increasing central area parking charges to $2.50 per day from the present average of $1.83 per space* would increase peak period modal split into the area from the current 47 percent to 57 percent. This would result in a 19 percent VMT reduction in the downtown parking study area, as illustrated in Figure III-1.

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* Downtown Baltimore Parking Study, Baltimore City Dept. of Planning, "Core Area Parking," April 1972.

However, this policy is applicable only to the Downtown Parking Study Area. Outside the parking study area, which is considerably smaller than the central area addressed in this study, there are currently few if any, lots with charges. The number of trip ends in the parking study area in Figure III-1 are approximately 35 percent of the trip ends in the larger central area referred to in this study. Further, approximately 50 percent of the trips in the central area are through-trips with longer average trip length in the central area. The net effect of these factors is summarized below:

```
   19 percent VMT reduction
 x .35 due to relative magnitude of downtown area
  6.6 percent
 x .33 to account for through-trip VMT
  2.2 percent VMT reduction
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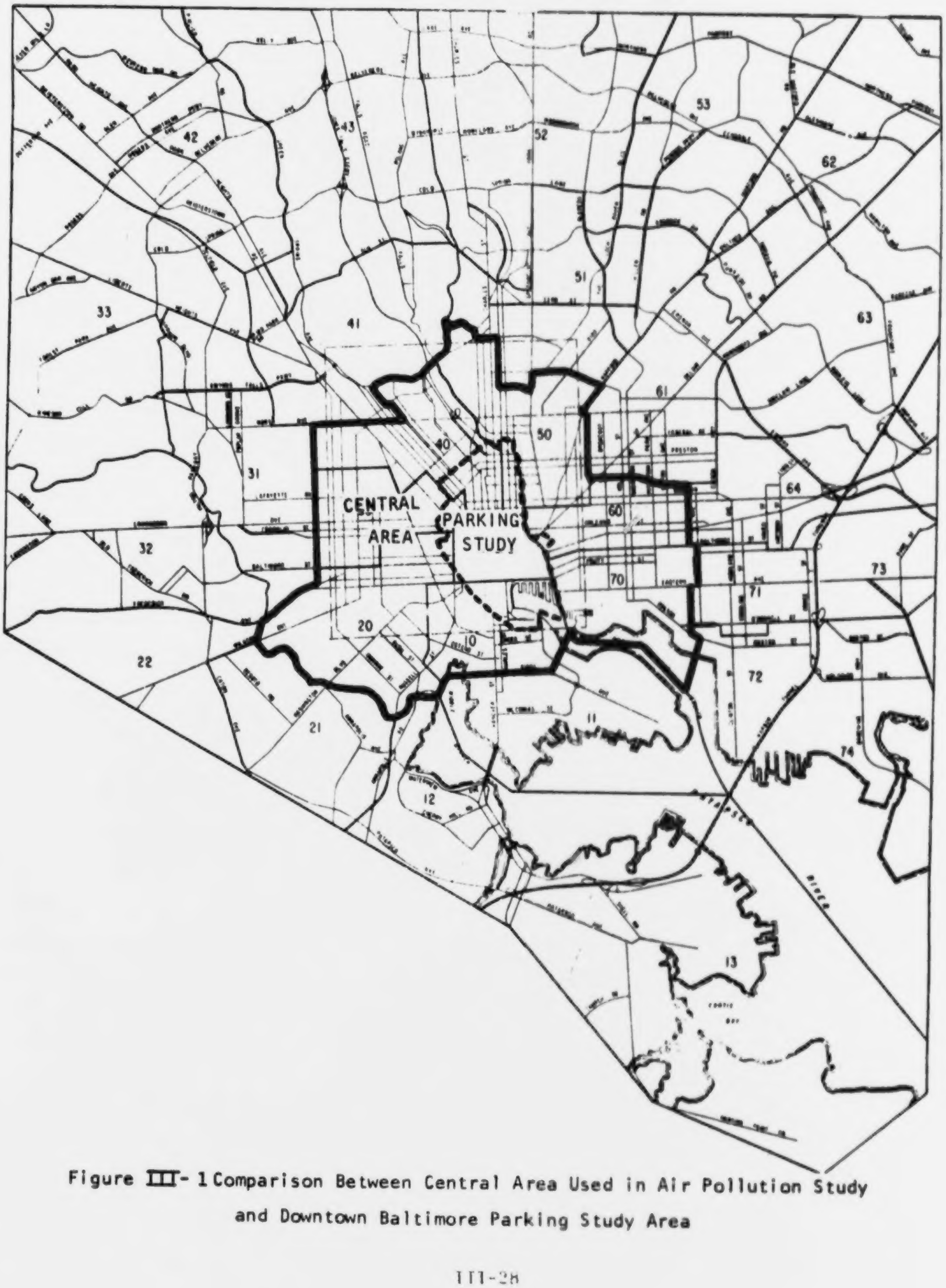
* Alan M. Voorhees & Associates, A Report on Mode Choice Analysis for the Baltimore Region, prepared for the Baltimore Regional Planning Council, 1969.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AREA
PARKING
STUDY
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Figure III- 1 Comparison Between Central Area Used in Air Pollution Study and Downtown Baltimore Parking Study Area

The overall VMT reduction in the central area is estimated to be between 2 and 3 percent.

The effect in non-central areas would be negligible.

Fringe Parking Policy - The possibility of developing fringe parking lots outside the downtown area was considered as an alternative for reducing downtown air pollution. Current plans call for several thousand new parking spaces to be provided outside the parking study boundary.

There are also currently existing two suburban fringe parking areas, with direct bus service to downtown, carrying a combined passenger load of approximately 2,000 persons per week.

In the Downtown Baltimore Parking Study, the effect of a close-in ring of fringe parking on downtown parking requirements was explored. The fringe lots were assumed to be just outside the parking study boundary which, therefore, places them inside the central area addressed in this study.

A survey of downtown auto drivers was conducted to determine the potential for fringe parking. The results were tempered by judgment, as it was concluded that 20 percent of the drivers who park over three hours on work trips would use such fringe spaces if the total cost for parking and transit service were lower than their present parking costs. It was concluded that such a program would divert 3,900 core area work trip parkers to fringe locations by 1975. Interpolating these results to 1977 would indicate a potential diversion of 4,100 parkers. The anticipated impact of this inner fringe parking policy is summarized below:

- 20 percent of long-term auto work-trips will divert.
- 40 percent of auto trip ends are work trips.
- 84 percent of auto work trips are long term.
- The parking study area accounts for only 35 percent of the central area trip ends.
- 50 percent of the traffic through the central area is through traffic.
- Through trips account for two-thirds of the VMT; therefore, the net VMT reduction in the central area is

  .2 x .4 x .84 x .35 x .33 = .008, or

  less than one percent of the central area VMT.

Eliminate On-Street Parking During Off-Peak Hours - While on-street parking in the downtown area is currently regulated by peak hour prohibitions and off-peak daytime meter charges, it has been estimated that enforcement is only about 75 percent effective. Any measure to improve adherence to these restrictions could be expected to result in some improvement in traffic flow.

Removing the 6,800 curb spaces in the parking study area during off-peak periods was judged to be an ineffective means of reducing the VMT as this type of regulation would not significantly improve traffic flow. In addition, the parkers potentially affected by such an action would be those contributing least to the air pollution problem and most to the economic base of the downtown.

Vehicle Free Zones in Central Areas - Much attention is currently being focused on proposals to completely eliminate automobiles in the central areas of major cities. Various types of auto bans have been adopted in a number of European cities, as well as in Japan. Several United States cities have experimented with street closings, as in New York, or have developed pedestrian malls, notably the Nicollet Mall in Minneapolis.

The city of Tokyo,Japan has banned automobiles from four shopping districts, comprising 122 streets, on Sunday, the busiest shopping day. Carbon monoxide concentrations were reduced substantially, typically on the order of 65 percent. Concomitantly, median street levels in the areas of the traffic bans were reduced by 5-7 dB/A.*

A similar action was tried in New York City on a much smaller scale, with a resultant 90 percent reduction in carbon monoxide levels on some auto-less streets.

During October of 1971, a series of experiments were conducted in the City of Marseilles to determine the air quality effects of motor vehicle restraints.* One experiment prohibited all private cars from entering the central area for a period of ten days. Nine kilometers of exclusive bus lanes were used to supplement existing transit service, and on one day all public transportation was free. The effects on air quality of limiting traffic to buses and taxis are shown in Table III-7.

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* Association pour la Prevention de la Pollution Atmospherique, Comite Marseille-Provence, as cited in Organization for Cooperation and Economic Development "Reducing Motor Vehicle Emissions through Traffic Controls and Transportation Policies" (working draft) 1971.

TABLE III-7

REDUCTIONS IN CO LEVELS-
CENTRAL MARSEILLES AUTO-FREE ZONE

Sampling Station	ppm of CO		Remarks
	before	after	
Banque Italienne	19.3	3.9	average of 7 readings/day at each location (8 a.m. - 6 p.m.)
Dames de France	19.4	2.8	
Magasin General	17.5	3.8	
Belle Jardiniere	18.9	4.0	
mean value	18.8	3.6	

Time	ppm of CO		Remarks
	before	after	
8 a.m.	20.2	5.5	average of readings at four locations
10 a.m.	19.8	3.3	
12 noon	14.7	3.6	
2 p.m.	14.2	2.7	
4 p.m.	19.8	3.3	
5 p.m.	20.3	3.9	
6 p.m.	22.3	4.1	

Before: September 13 - October 6, 1971
Total of 1,138 samples taken at 2-hour intervals

After: October 7 - 16, 1971 (ban on private cars; buses and taxis allowed).
Total of 496 samples taken at 2-hour intervals

Source: Association pour la Prevention de la Pollution Atmospherique, Comite Marseille-Provence, as cited in Organization for Cooperation and Economic Development "Reducing Motor Vehicle Emissions through Traffic Controls and Transportation Policies" (Working draft), 1971.

In spite of the rather impressive environmental effects of these policies, they were given low feasibility in Baltimore due to anticipated strong community opposition. In particular, fear of deterioration to the city's retail economic base was a major consideration. (It should be noted that historical data suggests an increase in retail activity accompanying such measures, in spite of early opposition to their adoption).* If the air quality problem in Baltimore is defined as a localized situation in downtown, this approach could be reconsidered.

3. Other Possibilities

Car Pools - Typical urban area auto occupancy for travel to work is 1.2 to 1.3 persons per vehicle. Through car pooling, the same number of employees could be accommodated in few autos. Car pooling could be encouraged by economic, social, or political means. Lanes could be reserved on expressways and city streets for the exclusive use, or combined use with buses, or car poolers. An information system could be developed to link people with nearby origins and destinations. Practical applications of car pool incentives have generally not been successful, however.

The potential impact of car pooling on VMT in the Baltimore region is extremely high. Surveys have indicated that the overall average occupancy on internal automobile trips in the Baltimore region is 1.48 persons per vehicle. This average conceals a wide range of occupancy rates for various trip purposes, ranging from a low of 1.14 persons per car for work trips to a high of 2.12 persons per car for trips made to serve passengers (i.e., taxi trips).* If the average vehicle occupancy could be increased to 2.0, a region-wide VMT reduction of approximately 25 percent could be anticipated.

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* Barton-Aschman Associates, Inc., Action Plan for Improvements in Transportation Systems in Large U.S. Metropolitan Areas; Auto-Free Zones; a Methodology for Their Planning and Implementation, prepared for the U.S. Department of Transportation, July, 1972.

Unfortunately, this potential for car pooling is illusory. The key issue is not what would happen if auto occupancy were raised to 2.0, but rather what response can reasonably be expected by encouraging people to form car pools. Potential incentives to encourage car pooling might include increasing parking charges, providing reserved lanes for car poolers, and providing a centralized information system to link prospective car poolers by origin and destination.

While the Baltimore modal split study develops an auto occupancy model with income level, parking cost, and highway travel time as independent variables, the model is merely descriptive and not policy-sensitive. Due to a high correlation between variables, it is impossible to use the model to predict the change in auto occupancy affected by, for example, increasing parking charges.

Providing reserved expressway lanes for car poolers is thought to be ineffective in Baltimore because the freeway system anticipated by 1977 will not be congested enough for separate car pool lanes to be an incentive.

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* Baltimore Metropolitan Area Transportation Study, prepared for the Maryland State Roads Commission by Wilbur Smith & Associates, 1964.

The possibility of forcing people into car pools by legislation does exist, but the probability of such an action would be negligible.

An interesting experiment was conducted in Los Angeles to measure the willingness of people to use car pools.* Two local citizens groups sponsored a so-called "Share a Ride Day" in which Los Angeles commuters were asked to share a ride either in a car pool or on a bus. In fact, a computer was available to link potential car poolers.

The Southern California Rapid Transit District set up special bus routes for the day. Local newspaper and radio stations gave much publicity to the attempt and over 100,000 handouts were printed and distributed to urge people to participate.

The California Highway Department, in a previous study, had found that the average vehicle occupancy on Los Angeles freeways was about 1.2 persons per vehicle. The results of the effort showed that "Share a Ride Day" had no significant effect on Los Angeles traffic. Average vehicle occupancies showed no significant change.

Staggered Work Hours - The practice of staggering work hours may be used to reduce peak-period travel volumes and traffic congestion by spreading travel demand over a longer period of time. This would tend to reduce the magnitude of pollutant concentrations; however, this technique is appropriate for localized air pollution problems related to peak concentrations in downtown areas, which are developed during the peak hour or two. Since the air quality problem in the Baltimore area appeared to be 8-hour carbon monoxide and regional oxidant levels, staggered work hour solutions in the central area were not appropriate for further consideration.

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* Phil Meyers and John Walker, "The Effects of "Share a Ride Day" on Los Angeles Freeways," Traffic Engineering, Aug. 1972.

It should be noted that there presently appears to be considerable staggering of work hours throughout the region. In particular, in East Baltimore, many workers start shifts about 6:00 or 6:30 a.m., and complete work around 3:00 or 3:30 p.m. This means highway and street facilities are more fully utilized during non-peak periods. For example, peak direction split Baltimore-Washington Parkway is 52-48 (as compared to 70-30 on facilities in other urban areas). This indicates a more constant level of travel in the Baltimore region under present circumstances.

Four-Day, Forty Hour Week - Although the 4-day, 40-hour work week presently encompasses a very small fraction of the labor force in the United States, it appears to be gaining in popularity at an increasing rate. In addition, a significant number of firms have adopted a 36-hour week comprised of four nine-hour days.

The possible effect of widespread implementation of revised work schedules on traffic volume, congestion, and air pollution, is difficult to predict, although indications are favorable. Peaking of traffic demand could be reduced by an amount dependent on the number of persons changing to modified schedules. In addition, on one or more days, the total number of work trips would be significantly reduced.

There is little knowledge of the overall effect on trip-making patterns that would result from substantial work schedule changes. There is some evidence to suggest an overall increase in trip generation due to a higher number of shopping and recreation trips.

Under the most ideal conditions, if 100 percent of the work force participated in a four-day work week, with 80 percent of the work force active on each day, a 20 percent reduction in work trips would occur. It might be possible to assume that 10 percent of the regional work force would be on a four-day schedule in 1977 if the concept were adopted by, for example, government offices. Since work trips make up less than 40 percent of the total trips, it is doubtful that the four-day, 40-hour work week could be expected to reduce VMT by more than 1 percent in 1977.

As with several other strategies, the 4-40 concept has a high potential, but without a specific mandate, the probable effectiveness is quite low. A deleterious side effect of widespread implementation of this policy could be the loss of transit ridership, due to a reduction of one round trip per week.

Increased Fuel Tax - It would require a substantial increase in fuel taxes to discourage automobile usage effectively in the urban area. The potential impact of such a strategy is difficult to predict, based on existing information. Small increases in the gasoline tax, such as recently imposed in Maryland and Virginia have had imperceptible effects on auto driving. People do not perceive user taxes in the same manner as out-ofpocket costs for transporation, and there is no experience with price elasticities of substantial gasoline tax increases on which to base an estimate.

Such a tax would probably have to be applied state-wide, which would have a regressive effect on residents in other parts of the state who are not affected by Baltimore air quality problems. However, funds collected by such a tax could be placed in the consolidated transportation fund which is allocated to all modes of transportation in the state. In the Balimore area, many people could avoid the tax purchasing fuel in adjacent states or the District of Columbia if uniform policies were not adopted.

D. SUMMARY EVALUATION

A number of possible control strategies have been described and a technical evaluation, based on a set of assumptions, has been developed for each. Table III-8 summarizes the reductions in emission rates or VMT reductions which may be achieved from each of these strategies. The reductions are not necessarily additive, and some are totally dependent on others, e.g., improved transit service must accompany increased parking costs, increased fringe parking, and reserved lanes. The reductions in emission rate from programs such as vehicle retrofit and inspection and maintenance must be applied to emissions after they are adjusted to reflect the strategies that would reduce vehicle miles of travel.

TABLE III-8

EFFECTIVENESS OF POSSIBLE TRANSPORTATION CONTROL STRATEGIES IN BALTIMORE

STRATEGY	EMISSION REDUCTION	SOURCE OF EMISSION REDUCTION
VMT-REDUCING STRATEGIES		
Traffic Flow Improvements	10% in all Areas	Increased Speeds
Transit Service Improvements	3% in Central Area 2% in Other Areas	VMT reduction by increased transit use
Reserved Lanes for buses	0.1% in all Areas	Same
Transit Fare Changes:		
15-cent reduction	7% in Central Area 4% in Other Areas	Same Same
Free Transit	13% in Central Area 14% in Other Areas	Same
Increased CBD Parking Charges	2.5% in Central Area 0.0% in Other Areas	Same
Increased Fringe Parking	1.0% in Central Area 0.0% in Other Areas	Same Same
Car Pools	1% in Central Area 0.5% in Fringe Area	VMT reduction by usage changes
4/40 Work Week	1% in all Areas	Same
Emission Reducing Strategies		
Inspection & Maintenance (I-M)	3.2% CO 4.0% HC	Direct % reduction in light-duty vehicle emission factor
I-M plus catalyst retrofit 1971-1974	17.6% CO 14.9% HC	
I-M plus catalyst retrofit 1968-1974	26.3% CO 23.0% HC	
I-M plus catalyst retrofit All Vehicles	30.5% CO 27.3% HC	
Heavy-Duty Retrofit Evap. & Crkcse.	0.0% CO 6.8% HC	Direct reduction of hvy-duty emission factor

In order to quantitatively apply the technical evaluations of the less effective strategies to the air quality problem in Baltimore, it might be necessary to re-evalunte the assumptions, revise as required, and recalculate, using the methodology described in the preceding section. This is particularly true of combinations of strategies, where one strategy might affect the assumptions underlying another. For example, if both reduced transit fares and CBD parking policies are considered, it will be necessary to adjust the assumptions for each, using the modal split analysis, to precisely determine the total effect. Since the air quality problem involves very sizable percentage reductions in emissions, however, the intrinsic uncertainty of the larger percentage figures can be expected to be of greater importance than the relatively-small non-additivity effects in the less effective strategies.

This is not to imply that the precise quantitation of strategy effects should be considered unimportant. The overall effect of the strategies could amount to a noticeable impact on the life-styles of Baltimore citizens, and more precise study may be warranted.

It should be further emphasized that the scope of this study did not permit analysis of the transportation effects of long range land use plans or major capital investment in any transportation facilities other than those presently planned and committed. Major changes in the planned highway or transit programs would require re-evaluation of expected impacts. It is noted that throughout this study, no major land use changes have been been assumed. The completion of the highway network, as input to the

Koppelman model (see Sub-Section II-C) is an important assumption. Should this not take place, the potential impact on VMT, particularly in the central area, could be important. It is expected this will be examined more fully in subsequent Regional Planning Council and Bureau of Air Quality Control studies. In particular, the present transit analysis is confined to buses, as it was assumed, based on a decision of the Air Quality Task Force, that none of the planned rail rapid transit system could be operational prior to 1978.

IV. IMPLEMENTATION OBSTACLES

A. OVERVIEW OF PLANNING POLICIES

The Metropolitan Baltimore Intrastate Air Quality Control Region is comprised of six political jurisdictions — Anne Arundel County, Baltimore City, Baltimore County, Carroll County, Harford County, and Howard County. Under Maryland Law, the City of Baltimore has autonomy in areas of law enforcement, taxation, and other metropolitan services within the city limits. Baltimore County has no jurisdiction in the City of Baltimore.

In addition to the political jurisdictions, there are several administrative and planning agencies at the state and local levels which are concerned with actions which could modify and/or control travel in the area. Most of these agencies are represented on the Baltimore Air Quality Task Force, an ad hoc committee formed prior to the beginning of this study to:

(1) Assess the immediate impact of alternative transportation plans on the Baltimore region.

(2) Determine how environmental considerations could be made a permanent part of the transportation planning process in the Baltimore region.

The Task Force is comprised of a representative from the following organizations:

Maryland Department of Health and Mental Hygiene-
Bureau of Air Quality Control

Regional Planning Council (RPC)

Interstate Division for Baltimore City

Maryland Department of Transportation

Maryland Department of State Planning

Federal Highway Administration - Maryland Division

Washington Metropolitan Council of Governments

Baltimore City Planning Department

Baltimore City Mayor's Office

Baltimore City Health Department

During the study period, the Task Force met frequently with the Contractors and EPA to monitor progress. In addition, individual interviews were held with members of the Task Force to obtain more detailed information than was available at the meetings. Other representative agencies contacted include:

State, County, City Organizations:

- Mass Transit Administration (MTA)
- Baltimore Department of Transit and Traffic
- Baltimore Department of Highway and Community Development
- Maryland Motor Vehicle Administration
- Maryland Gasoline Tax Division
- Baltimore County Planning Department
- Baltimore County Traffic Engineering Department

Non-Governmental:

- Baltimore Bus Operators

Taxicab Association of Baltimore City
Maryland Motor Truck Association

The Task Force includes all agencies involved in the "3-C" transportation planning process as required by the Federal-Aid Highway Act as well as the A-95 review responsibility. This authority is vested with the Regional Planning Council.

RPC was established as an independent state agency by the Maryland General Assembly in 1963 in order to deal with the problems of rapid urbanization in a rational and sound manner. The Council is required to prepare a suggested general development plan — a plan which will provide for the effective employment of natural and other resources of the region, and which will assure a continuous comprehensive planning process within the region. The RPC also serves as a coordinating agency 1) seeking to harmonize and advance its planning activities with those of the state and of the counties and municipalities within the metropolitan area; 2) rendering planning assistance; 3) stimulating public interest and participation in planning for the development of the area; 4) serving as the referral agency for problems affecting more than one unit of government; and 5) reviewing local government programs and federal grant-in-aid requests when required by law. The Technical Advisory Committee of RPC has also monitored the activities of this study.

1. Baltimore

The City of Baltimore, through the goals and priorities that have been enumerated in the guidelines for the city's development, has indicated a concern for the impact of motor vehicles on the urban environment. These guidelines are documented in the comprehensive plan for Baltimore City as adopted by the Planning Commission. The plan includes goals and policies to guide the city's physical and social development, as well as analyses of city's needs and resources and recommended patterns of development.[*]

Policy statements have been developed to provide a series of guidelines, for specific functional areas such as transportation. These policies have a bearing on the implementation of the transportation control strategies that have been suggested:[**]

- The development of a system of major streets and highways that will allow vehicle movement with a minimum of disruption to the city and the region. The emphasis should be on the diversion of traffic away from the CBD.
- The city shall investigate the options open to it in the development of an intra-CBD distribution system to determine which mode or combination of modes will stimulate economic activity while reducing the need for automobiles in the downtown area.
- The city shall encourage the rational expansion of the trucking industry in a manner consistent with its goals of enhancing and preserving the environmental of the city.
- The city should actively support and encourage the development of programs aimed at the minimization of the harmful impacts of transportation in the environment.

An area plan has been formulated as a comprehensive concept plan for MetroCenter,[***] which includes the CBD, University of Maryland,

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[*] Baltimore City Planning Commission/Department of Planning, Baltimore's Development Program 1972-1977, August 1971.

[**] Department of Planning, Baltimore: Transportation Facilities and Services, Baltimore Maryland.

[***] Wallace, McHarg, Roberts and Todd, MetroCenter/Baltimore Technical Study: A Report of the Regional Planning Council and the Baltimore City Department of Planning, 1970.

Inner Harbor, Mt. Vernon, and Mt. Royal Plaza, and Camden Industrial Park, and provides an integrative framework for component sub-area plans.

The Charles Center and CBD plans first articulated the goals for MetroCenter. Several of the strategies that were developed are also important as parts of the process designed to preserve the urban environment. In brief, these include:

- Separation of vehicular and pedestrian traffic wherever possible.
- Greater dependence on an efficient transit system.
- The development of modern traffic patterns and distribution systems linking downtown with the expressway system and the region.
- The diversion of through-traffic away from downtown streets.
- The provision of adequate off-street parking for all activities concentrated immediately adjacent to the uses it serves.
- Burying the automobile underground when not in use.

A basic part of the MetroCenter concept is a concern with the control of vehicular movement. The MetroCenter plan relies on a network of delivery spurs and boulevards to link the Interstate highway network to city arterials rather than the traditional system of expressway rings.

Parking is another element in the movement system on which MetroCenter has focused to some extent. A recommendation has been made that a substantial amount of the required parking be placed underground, or within parking structures in order to alleviate congestions on downtown arterials.

Linked to the question of parking is the emphasis on the development of the rail rapid transit system. This is seen as a method of reducing the long-range need for parking. The recent parking study* shows that without the proposed rapid transit, 13,600 more parking spaces would be required if the downtown area is to achieve its growth potential. Further expansion of the downtown shuttle bus services, perhaps including free CBD bus connections to all parts of MetroCenter, was recommended, as was the idea that bus routes should serve transit stations and fringe parking terminals in order to encourage people to leave their cars outside the CBD.

2. Baltimore Development Program 1972-1977

To guide the city in making necessary physical improvements, the charter requires the Planning Commision to prepare annually a six-year recommended capital improvements program which is issued as Baltimore's Development Program.** The list of recommended projects is prepared by the Planning Department after reviewing the requests of the various city agencies. Subsequent additions and deletions are based on the Comprehensive Plan, the city's overall priorities, the expressed needs of the citizens, the merits of each project, and the financial constraints imposed by the Board of Estimates Policy and Federal and state restrictions on the use of intergovernmental funds. Only City Council approval of the first year of the Development Program as part of the city Budget actually commits the city to finance projects. One of the advantages of this process, however, is that it implements the city's comprehensive Development Plan, in the short term.

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*Wilbur Smith and Associates, Baltimore Parking Study Technical Report, 1970.

**Baltimore City Planning Commission/Department of Planning, Baltimore's Development Program 1972-1977, August 1971.

The Development Program has recommended an appropriation of $1,529,861,000 for the period 1972-1977. The increase over that for 1971-1976 is a result of the accelerated schedule for the construction of the interstate expressway system, as described above.

Baltimore City participates in a unique financing system for state-assisted transportation programs. A block grant is provided to the city to fund police services, highway maintenance, debt service on revenue bonds, and Federal-Aid highway matching funds. The amount allocated by the state in 1972 was $35 million.

The specific functional areas of interest for this study are appropriations for the Department of Transit and Traffic and the Off-Street Parking Commission. The Department of Transit and Traffic will begin an extensive modernization of the existing digital traffic control system. The computerized Traffic Command and Control System will cost approximately $5 million and is expected to be fully operational in three to four years. (Bids will open for hardware, software, equipment, and installation in

December, 1972.) The Planning Commission recommended appropriations of $1,329,000 from State DOT funds and $228,000 from Federal funds for the first fiscal year.

The Planning Commission has recommended a Capital Improvement Program of over $22 million for off-street parking. The specific physical recommendations rely heavily on the downtown parking needs that were outlined in the parking study.*

The two basic policy objectives to be implemented in the six-year program are 1) the use of existing and future parking facilities in the CBD for short term trips, and 2) the creation of fringe parking and rapid transit facilities for commuters making trips of longer duration. The parking facilities planned to meet the stated goals are described below.

The total cost of implementing the comprehensive plan for downtown parking is approximately $33 million. Of this total, $5 million is for the hospital; $6.5 million is for Inner Harbor development; and $17.5 million is for the proposed fringe are parking facilities. The remaining $4 million include parking for the new government center, the University of Baltimore, the Inner Harbor Campus of the Community College of Baltimore, the downtown department store area, and the North Central Core of the CBD. The 1972-1977 Development Program provides sufficient funds to complete this comprehensive plan by 1980.

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*Witben Smith and Associates, 1970 Report.

The elements in the Program will be financed using several already existing mechanisms. The Planning Commission has recommended that most of the parking facilities be financed through the issuance of revenue bonds. A $3 million revenue band issue was recently passed for institutional parking. A second recommendation is that three large joint development fringe parking garages that are being planned be financed jointly — 50 percent local and 50 percent Federal under the Federal-Aid joint development. Finally, the Commission has suggested that the college and the hospital parking be financed through the Maryland Health and Higher Education Facilities Authority.

3. RPC Transportation Plans

The plans for the Baltimore area which have been described do not exist in a spatial vacuum, but rather are linked into a regional planning process. The Regional Planning Council has formulated a plan which includes three major systems: highways, public transportation, and other transportation modes. It has been recommended that this plan be seriously considered by the Maryland DOT for inclusion in the proposed state master plan for transportation. In addition to the capital improvements detailed in the plan, implementation of the following related transportation policies are equally important to its success:*

- Improve bus transit service
- Locate residential areas and employment activities so as to reduce commuting distances

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*Regional Planning Council, General Development Plan, Baltimore, Maryland, September 1972.

- Encourage more restrictive parking policies to stimulate increased transit ridership and car pooling
- Encourage modifying work shift patterns by large employers to reduce sharp peaking of commuter travel.

This plan also places particular emphasis on the development of the regional rapid transit system. Two types of system have been specified and are tied into surrounding centers and communities by a high frequency feeder bus system. A high speed, high volume rapid transit service is planned for major travel corridors which connect high density residential areas with major employment and regional centers. Express and limited bus service is planned in lower density corridors requiring rapid transit service where the connecting highway system is adequate to provide reliable high-speed service.

The cost of implementation of the recommended rapid transit system will require an investment of $1.7 billion. Construction of the 28-mile Phase One rail rapid transit system is expected to start in 1974. The total Phase One system is estimated to cost $650 million. In addition to capital expenditures for rail rapid transit, several million will be required to upgrade the bus system to meet service needs.

B. VEHICLE INSPECTION AND MAINTENANCE

A recommendation for a state emission inspection and maintenance program is often associated with motor vehicle safety inspection programs. However, the State of Maryland does not presently have a periodic safety inspection for all in-use motor vehicles, although the adjacent states of

Pennsylvania and Virginia and the District of Columbia do have such programs. Maryland does have a law requiring a safety inspection of used cars at the time of sale, which is estimated to cover about 15 percent of all vehicles annually. There are about 1,200 licensed inspection stations and approximately 2,300 mechanics are certified to perform this service. The charge for this service is about $6.00, based on the average mechanic's fee for 45 minutes to one hour of labor, payable to the licensed station which performs the service. An additional $2.00 fee is collected at the time of transfer of title to finance the program, which is administered jointly by the Motor Vehicle Administration and the State Police.

1. Legal Obstacles

Prior to the 1972 legislative session, a task force report* was prepared which recommended a system of regional state-operated stations to provide periodic motor vehicle inspections (PMVI), including emission testing and optional diagnostic tests for passenger cars and trucks. The major bill in the legislature which incorporated the task force recommendations did not pass. This legislation was part of the State's overall safety program but did not have a high priority.

A similar bill has been prefiled for the 1973 session of the legislature and is again in the safety package presented to the Governor by the Motor Vehicle Administration. (The bill was not available for review when this report was prepared.) PMVI again has a relatively low priority, but the Governor may readjust the position before presenting the 1973 legislative package.

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*System Design Concepts, Inc., et al., Maryland Periodic Motor Vehicle Inspection, prepared for the Task Force on Periodic Motor Vehicle Inspection, Washington, D.C., December 1971.

Probabilities of passing the PMVI in 1973 are not high, based on the expected safety priority status, the capital and operating costs, and the possible reluctance of legislators to reinstate an inspection system. (Maryland had a system of inspections, conducted by private garages, which was not well controlled and eventually was written out by law in 1965.)

The PMVI program was sized for emissions testing, but procedures were not specified pending recommendations from EPA on evaluation of short-cycle testing methods. In addition, the program called for reinspection of rejected vehicles. The repair of rejected vehicles was to be provided in the private sector at the owner's expense. The task force report recommended a training program to include training in inspecting and maintaining air pollution control devices.

Among the factors which may work toward passage of PMVI in 1973 are the emissions and diagnostic testing phases. If the air quality problem is identified as severe enough to warrant extensive measures for control, the implementation of such a plan, based on safety inspections, will become more apparent. Inspection and maintenance may necessarily be viewed as an enforcement mechanism to achieve and maintain air quality by 1977.

Another factor is the Federal requirement that states have a periodic motor vehicle inspection program under the Highway Safety Program enacted in 1966. The Secretary of Transportation has discretionary power to place a 10 percent penalty on all federal-aid highway funds apportioned to the State. Maryland, however, ranks 15th in safety performance, although the State is required to show significant progress toward meeting the safety standards, including safety inspection.

2. Institutional Obstacles

One of the main purposes of the proposed PMVI is to establish an integrated, coordinated, statewide plan under Maryland DOT. This is best fulfilled by enacting the total system, including, in addition to safety and emission inspections, District Courts, and driver examination centers.

The joint administrative and enforcement role of MVA and State Police has already been established and would be further reinforced by the integrated State inspection stations. Emissions testing and enforcement would probably add the Department of Health and Mental Hygiene to the administrative framework.

3. Political Obstacles

The political climate has been outlined above in the discussion of the enabling legislation. The possibility of implementing the program for Baltimore only, or for emissions inspection only, does not appear likely, unless this were done at the discretion of the Governor to enforce emergency powers.

4. Economic Obstacles

Because the most feasible inspection-maintenance program for Maryland is tied to the planned statewide safety inspection program, the total capital costs are high. The original plan called for 19 stations located throughout the State. The Baltimore region would have six of these stations. The estimated implementation cost in 1972 was $33 million; this figure, however, did not include the cost of emissions testing equipment, which could result in a total capital cost of $35 to $40 million, depending on the type of testing equipment and mode required by EPA, as well as inflationary factors. Funding required could be achieved through the Maryland Department of Transportation, through issuance of consolidated transportation bonds or revenue bonds.

Consolidated transportation bonds can be issued by the Secretary of the Department of Transportation, with approval from the Board of Public Works. Constitutional limits on these bonds appear to be 15 years. Revenue bonds can be issued by the Maryland Transportation Authority and must be retired from fees in 40 years.

Operating costs were estimated at $8 million per year. Fees would be collected to repay revenue bonds. Additional funds would probably be required to subsidize operations.

Other funding sources are available through Federal programs such as diagnostic testing demonstration centers or recent legislation to provide for pilot emission testing sites in selected cities.

5. Technical Obstacles

While the PMVI program appears to be the most feasible method for implementing an emissions inspection and maintenance program, one major obstacle appears to be the time frame. It has been estimated that the entire program would require two to five years to become operational. It might be possible, however, to complete the Baltimore area stations to implement the 1977 State air quality plan if the total program package were adopted. A phase-in program was recommended by the task force.

Another factor is that emissions testing procedures have not be promulgated by EPA which means that it is not possible to evaluate off-the-shelf technology. Should the PMVI program be adopted, the Baltimore region could serve as a good test site.

Much of the effectiveness of the program will depend on the rejection rate. In the initial stages the rejections could be high due to several causes, including inexperience of personnel or the relative ease with which control devices can be made ineffective. Much would also depend on the criteria set for rejection.

C. TRANSIT STRATEGIES

Since mid-1971, all transit functions in Baltimore City have been the responsibility of the Mass Transit Administration (MTA) of the Maryland Department of Transportation. The Baltimore Transit Company had been purchased in 1970 by the redecessor agency, the Metropolitan Transit Authority. MTA is responsible for planning, programming and implementing mass transit services in the Metropolitan Transit District, which is comprised of Baltimore City, Baltimore County, and Anne Arundel County. MTA plans to take over four suburban transit companies early in 1973. Thus, the entire metropolitan transit system will be state-owned and operated (Baltimore management is presently under contract to a private firm).

In addition to bus transit, MTA is planning and developing the regional rail rapid transit system in coordination with the Regional Planning Council. The Urban Mass Transportation Administration has recently granted $22.5 million to help finance construction of the first phase of the system. The local one-third funds will come from the Maryland Department of Transportation.

There are few apparent legal or institutional obstacles to improved transit services, or even reduced transit fares at the state level. Local policy supports transit and could generally benefit from more transit ridership. There is a question of economic policy, however, related to the mandate of MTA to support all costs incurred for construction, acquisition, operation, and maintenance of transit facilities "as far as practicable" from the fare box and Federal funding grants. Presently there are no funds available from Federal sources to subsidize operating losses; therefore it would be necessary for the state to review policy related to operating losses caused by new services or reduced fares.

Present planning calls for many transit service improvements, including acquisition of 100 new buses in 1973. An application to UMTA to support this plan will be submitted in January. The transit technical study (T9-5) is in the review stages, but it may be expected to recommend further service improvements.

D. PARKING STRATEGIES

1. CBD Parking

An important element of any overall strategy to reduce the amount of automobile emissions is to control the flow of traffic into the congested areas. One approach that should be considered is the manipulation of the demand for parking in specific locations. This is very feasible in areas where a parking shortage exists.

Specifically there exists in Baltimore a shortage of spaces in the core area, caused, to a large extent, by an overwhelming number of long-term parkers. The magnitude of the problem has been quantified in the parking study mentioned previously. Due to changes in land-use and natural growth, this deficit will increase. The current plans propose to deal with it through the combined development of fringe parking and rapid rail transit —

in this way providing alternatives for those who would normally park in the CBD. However, from the perspective of controlling cars by controlling the supply of parking three strategies have been considered:

- Increased parking charges in the CBD
- Provision of CBD fringe parking lots
- Provision of suburban fringe lots

These will be evaluated in terms of feasibility of implementation and the obstacles to implementation.

a. Increased Parking Charges or Taxes in the CBD

Presently, in Baltimore hourly parking charges range from $0.35 to $0.85 for the first hour and from $0.50 to $2.85 for all day parking. The charge for lots as well as for metered spaces varies with the location. These rates however are, on the average, lower than those of other cities of comparable size.

There are, in addition to the privately operated lots, six interim, metered surface parking facilities monitored by the Department of Transit and Traffic, ranging in size from 49 spaces to almost 300. They are "interim" lots because they are located on urban renewal land. The charge at the Charles Center lot, the smallest, is $0.40 per hour with a 4-hour maximum; the others charge $0.25 for 2-1/2 hours, with a maximum of 10 hours. These rates are slightly below those of the other lots in the city. This has the effect of keeping the other rates down. The lower cost also makes them somewhat more attractive to commuters. A study recently completed by the City Planning Department on these six interim lots however indicated that their attractiveness was almost evenly split between location and cost. Another interesting finding, from the same study, was that 10 percent of the drivers interviewed had switched from some other mode to the automobile, either because of cost (in some instances it is cheaper than the bus) or convenience, although many had some distance to walk to reach work sites.

Results of this type indicate that the convenience and comfort aspects of fringe parking plus well-routed rapid bus service may have more impact on commuter modal choice than the negative incentive provided by increased parking costs.

A strategy to increase parking charges, aside from questions of its efficacy, faces several types of implementation obstacles.

b. Institutional

A basic obstacle is the structure of the off-street parking commission. The commission was formed for the purpose of providing financing at low rates for private entrepreneurs interested in developing parking facilities. The city provides capital construction funds through issuance of revenue bonds and indicates where it would like the facility. Other than this, the commission has only review power over the rates charged by the individual operators. The only lots over which the city has direct control are the six interim lots previously mentioned. This represents

966 spaces, and could provide some leverage for an upward shift in the rate structure. Other lots charge lower prices because of them and a general upward price would probably be followed by private operators.

c. Legal

There are, in addition, legal obstacles to any attempt on the part of the commission to regulate the price set by private business. For while there are presently no specific laws forbidding it, the assumption of this type of power would immediately be challenged in the courts on constitutional grounds. Presently, the situation is further complicated by the price controls that have been instituted by the Federal government.

As an adjustment of the basic rate structure is not really feasible, there are several less direct methods that pose no legal problems. An adjustment of the $0.15 transaction tax might provide a method of increasing the cost of parking. The tax was levied by the city for revenue purposes, originally at $0.10 and recently raised to $0.15. It is a flat rate on all parking in lots or garages and there are no legal limits on the amount to which it could be raised.

Increased property taxes on the parking structures themselves might also cause rates to be raised. Presently the owners are taxed only at the value of the undeveloped property. If they are taxed at the value of the developed land, it is conceivable that the increase will be passed on to the consumer.

Finally, increased construction costs due to a cutback in low-interest city loans, may also be reflected in increased costs to the consumer. However, as the demand for construction applications is not great this would have a minimal effect.

d. Economic

Although these indirect techniques for causing price increases have no legal obstacles, a consideration of the economic impact of such an action may provide an effective deterrant to city policy-makers.

A general price-rise, would be unselective, discouraging long-term parkers as well as those coming into town to shop. There is a great fear on the part of the city's merchants, that any obstruction to the flow of traffic into the CBD will jeopardize the commercial vitality of the downtown. It is difficult to assess the potential magnitude of this problem as there is no accurate way of determining how many potential shoppers, discouraged by high parking charges in the CBD, will turn to the suburban shopping centers for their needs, rather than taking transit into town. For example, San Francisco, imposed an increased parking tax and downtown merchants experienced a decline in the volume of business.

One way of avoiding this generalized result would be to selectively raise the tax with the goal particularly of discouraging the commuter. Rather than a flat rate an incremental increase after 3 hours might be imposed. This would tend to discourage all-day parkers who drive into town for work, rather than penalizing shoppers.

e. Political/Social

Any attempt to raise prices for services will generate political opposition. The present parking tax, as low as it is, is generally unpopular with commuters and with businessmen, many of whom are part of a downtown merchants group designed to lobby against just such issues. Any increase will create additional problems for city government whose basic policy is to keep parking rates as low as possible to maintain a viable center city. Consequently, it is doubtful that it will willingly implement strategies that lead to other results. This is particularly true of this situation where an excessive increase may be necessary to divert commuters to public transit.

f. Technical

The technical obstacles to this solution have been discussed in the strategies section.

2. CBD Fringe Parking

The Baltimore parking study has indicated that because the largest percentage (nearly 40 percent) of downtown Baltimore parking is for work trips, the need to meet these long-term parking demands is the most significant parking requirement for the central core area. Increased use by downtown employees of public transport, coupled with the development of fringe parking facilities could reduce future need to develop extensive parking facilities in the central core area. Positive incentives such as lower cost, convenience and comfort could promote mode changes in a way the increased CBD parking rates will not.

Presently three sites have been selected and are being studied for construction of fringe parking terminals. They are: (1) a 1,779-space structure to be located at the point where the proposed I-170 spur will intersect the proposed new boulevard; (2) a 1,000-space air-rights structure above the Baltimore and Ohio railroad yards, with direct access to the proposed I-395 spur; and (3) a 600-space garage adjacent to I-83.

As part of the total transit system, the terminal at I-170 would be served by the planned rail rapid transit system, providing a transfer point for motorists who ride the transit system to the core area. Transportation from the terminal would be provided by a shuttle-bus service. The terminals at I-395 and I-83 are not linked to the proposed rail rapid transit, but would be served by rapid bus.

The obstacles to this strategy lie, to a large extent, in the areas of coordination of services and development of funding and operating procedures.

a. Institutional

The planning and implementation of these terminals rests with the Bureau of Joint Development ot the Interstate Division for Baltimore City. The goal is to coordinate these parking facilities with the Interstate highways serving transit under the Joint Development provisions of the Federal-Aid highway programs.

b. Legal

The primary legal problem is related to the acquisition of the land. The site selected for the terminal adjacent to I-70, although not in the existing condemnation corridor, falls within an NDP area which should facilitate acquisition. The land for the other two terminals, however, would have to be obtained through condemnation. Because of the legal disputes surrounding the construction of some of the highways the public may not be enthusiastic about the idea of parking terminals.

c. Economic

The highway act provides for 50 percent from Federal and 50 percent from local matching funds. The city would derive funds from the sale of bonds and by tapping the State gasoline tax fund. The Federal program would finance up to 50 percent of the cost of parking facilities located at the fringes of the downtown area — provided that the garage serves (primarily) freeway type traffic before it reaches local streets. There appears to be no local financing problems, and the city has programmed funds for the terminals in the six-year Development Program.

No steps have been taken to approach the Federal Highway Administration for capital funds; therefore, the probabilities of Federal funding are uncertain.

d. Political/Social

The idea of CBD fringe parking terminals is one that has the support of the planning commission and the city government. There may be some opposition from downtown merchants. The obstacle is that there is no local constituency to support it. The commuter has to be convinced that transit is a less costly and more convenient mode than the automobile, and until this is done the potential market will not be realized. The issue of the determination of the user charge for these facilities will have a great bearing on their attractiveness to the commuting public. Although the parking study indicated that people are more influenced by convenience than by cost, it will still be necessary for the fringe parking charge plus transit to be less than the parking rates in the CBD.

e. Technical

Because the success of the CBD fringe parking concept depends on the consumer's perception of increased convenience, coordination of terminal construction and initiation of the rapid bus system is particularly important. Synchronization with the proposed rapid rail system is not essential for this strategy to be initiated.

The timing and coordination of the construction schedules for the expressways and the terminals that relate to them must also be taken into consideration. It is likely that the highways will be completed before the terminals. If this occurs, it is possible that the commuters will adjust to this improvement and will be disinclined to use the terminal facilities when they are provided. The relationship of these facilities to phased rail rapid transit is being studied.

3. Suburban Fringe Parking

This type of facility is designed to service suburban areas on the outer side of the Beltway. Using the facilities already provided by shopping centers, spaces are provided for commuters to leave their cars and take the rapid bus service into the city. To date two shopping centers, GEM East and GEM West, are being used by MTA for this purpose. Each area provides 200 spaces; it is estimated by MTA that approximately 100 at each are used. The bus service is used by 2,000 people per week which requires seven vehicles per day. There is no charge for the parking and the bus fare is $0.50 each direction, which is comparable with competing fares.

a. Political/Social

There are no political or social obstacles, as the groups affected by this service seem to be pleased. This includes the merchants who provide the spaces. They see participation in the provision of parking space at suburban lots as a form of advertising.

b. Technical

The availability of potential sites does not present an apparent obstacle to the continued existence or expansion of suburban fringe parking. There are numerous shopping centers in the vicinity of the Beltway, and businessmen seem interested in participating in future development.

The "Metro Flyer", an express bus from the Towson area also serves a shopping center as well as some residential areas. The 15-mile trip to the Baltimore CBD utilizes the Jones Falls Expressway. This is presently run by a suburban bus company, but MTA expects to take over the company by early 1973.

c. Institutional

Although MTA has negotiated for these fringe parking sites, further expansion of shopping center use would probably require greater participation from Baltimore County. In earlier negotiations, not all centers were interested in permitting their lots to be used for park and ride services. Both the government and the consumer indicate approval of the system, as is indicated by the number of new riders who have been attracted to transit because of it, an attitude which will facilitate making improvements.

d. Legal

At present there is no problem with land acquisition. The shopping centers have given the MTA the right to use the space. If the situation should arise that the merchants require the spaces for their own use, there could be problems in moving the facility to some other center or in seeking and purchasing other land.

e. Economic

The spaces are provided at no cost to the authority and the $0.50 bus fare covers the operating costs. Presently the operation is breaking even; however, this position is not likely to remain stable with rising operating costs. Large costs might be incurred if land purchase is required.

E. CAR POOLS

As the idea of car pools is a recent development, few formal obstacles exist to hinder its effective implementation. However, as with incentives for public transit, the negative attitude of the public must be overcome before it can be effectively used.

The implementation strategies that seem most feasible for Baltimore, in addition to the imposition of severe parking restrictions in the CBD are:

- The institution of a system of priority points for existing spaces and the related idea of parking
- Lower parking rates for people in car pools

1. Institutional

Employers who are already using another type of priority system (seniority) may be unwilling to change, as it would most likely be unpopular with the employees. In areas where government buildings predominate the institution of this type of policy would be possible.

2. Legal

If large employers institute this system voluntarily, there are no legal obstacles. If, however, the city government chooses to adopt this as a city-wide strategy, there is the likelihood of legal action on the part of private business.

3. Economic

This type of policy has no real implementation costs, unless some type of monetary incentives are required to convince private business to participate.

4. Political/Social

There are no stated objections on the part of city government to car pooling. However, disatisfaction on the part of commuters may result in pressures that will limit the action taken. The basic obstacle again is convincing the commuter of the advantages of car pooling.

5. Technical

Positive incentives for car pooling will be most effective if they are instituted in close coordination with some disincentives for CBD parking. Aside from this possible obstacle, from a technical standpoint it would not be difficult.

6. Lower Rates

As this strategy is a variation of the priority points system, and is closely related to changing parking rates, the obstacles are similar and need not be reiterated.

V. RECOMMENDED CONTROL STRATEGY

A. RATIONALE AND RECOMMENDATIONS

In order to facilitate comparison of the several candidate strategies with respect to both their effectiveness, discussed in Section III, and their social feasibility, discussed in Section IV, numerical ratings were applied to each of the various aspects considered.

The numerical ratings, summarized in Table V-1, were based on judgment, interviews with local representatives, and expression of value judgments at Task Force meetings. Depending on the level of application or enforcement, i.e., whether a 15-cent or a zero transit fare were being considered, these ratings could be adjusted accordingly. Criteria used in evaluating the strategies were:

- Technical effectiveness - ratings are recorded separately for the central area and the region; criteria are the amount of emission reduction and the relative transportation effects.
- Legal feasibility - Status of existing legislation; requirements and obstacles to passage of new legislation; enforcement measures; discriminatory impacts.
- Institutional feasibility - Administrative and operating staff, facilities, authority; state vs. city and county interests; private concerns.
- Social/political feasibility - Compatibility with local, regional, state, and Federal goals; impact on individual mobility; effects on low-income persons.
- Economic feasibility - Capital costs; operating costs; funding sources; individual burdens; impact on bonded indebtedness.

TABLE V-1

SUMMARY OF EFFECTIVENESS AND FEASIBILITY OF
POTENTIAL CONTROL STRATEGIES

	Effectiveness		Feasibility				
	Central Area	Fringe & Suburb	Legal	Institutional	Social/ Political	Economic	Overall Feasibility Rating
Vehicle Retrofit (pre-1975 vehicles)	4	4	1	2	1	1	1.3
Inspection and Maintenance	4	4	3	2	3	3	2.8
Traffic Flow Improvements	4	2	5	5	5	4	4.8
Transit Service Improvements	2	1	4	4	5	3	4.0
Reduced Transit Fares	4	2	2	3	3	3	2.8
Reserved Lanes	1	1	3	3	4	4	3.5
Car Pools (voluntary)	1	1	-	5	2	3	3.3
Motor Vehicle Use Restraints							
Increased Parking Charges	3	-	3	1	2	3	2.3
Increased Fringe Parking	1	-	3	2	2	2	2.3
Four-Day-Work Week (voluntary)	1	1	-	2	3	3	2.8

Ratings are based on a scale of 1 - 5 with 5 representing the highest effectiveness or feasibility.

Broad consideration was given to trade-off effects, such as the potential reduction in transit riding due to car pooling or a four-day work week. The overall feasibility rating was a simple average of the 4 rating parameters, except that no legal ratings were given to the voluntary strategies. The voluntary programs, car pooling or four-day work week, would have more potential if made mandatory, but would surely have a minimum feasibility.

To meet the National Primary Ambient Air Quality Standards in 1977, the Baltimore urban area must reduce expected 1977 carbon monoxide levels in the Central Area by 36.8 percent, and expected hydrocarbon emissions 40.0 percent area-wide during the 6-9 a.m. period. Since there are non-vehicular sources in the region, the required reductions are even higher proportions of the emissions from motor vehicles only - 38.3 percent and 56.0 of the Central Area CO and the morning peak hydrocarbon emissions, respectively.

It is apparent from the general run of effectiveness levels in Table III-8 that there is a minimum of choice involved in selecting a combination of strategies that will meet the standard, and Table V-1 emphasizes that it will likely be impossible to select a combination that will both meet the standards in 1977 and meet with general approval. There is in fact a definite trend for the most effective strategies to be rated least feasible.

The two strategies with the highest combination of feasibility and effectiveness are traffic flow improvements and a control-device inspection and maintenance program. Between them, however, they can effect only a 20 percent reduction in CO emissions and a 22 percent reduction in hydrocarbons.

Further inspection of Table III-6 brings the conclusion that no combination of strategies can meet the standards unless it includes a program of retro-fitting pre-1975 vehicles with control devices. Because of the very poor acceptance rating of a retro-fit program (largely due to its cost), this is of course an unwelcome conclusion, though an unavoidable one. Consequently, the recommended combination of control strategies includes compulsory retrofitting, as well as other, more desirable strategies.

A combination of the most desirable and the most effective strategies, including a retrofit program, inspection and maintenance, total subsidy of transit fares, and traffic flow improvements, is, however, still insufficient to provide the required hydrocarbon reduction, although it does meet the carbon monoxide requirement. Since this program gains the maximum possible reduction in emissions from light-duty vehicles, the balance must be sought from heavy-duty vehicles or non-vehicular emissions. The latter were presumed to be already controlled to the maximum extent possible, although that assumption should be re-evaluated by the State in the light of the severity of the problem. Accordingly, the further hydrocarbon reduction needed was sought from heavy-duty vehicles, and a program of retro-fitting evaporative and crankcase controls proves to be sufficient.

Accordingly, it is recommended that the overall control strategy include:

1. A comprehensive program of minor re-design and construction, and improved signalization and channelization.
2. A program of improved bus transit service improvements designed to attract usage by reducing both access times and line-haul times.
3. The total subsidy of transit operations to provide free transit service.
4. A program of mandatory retro-fitting of pre-1975 model light-duty vehicles with oxidizing catalytic converters equivalent to those on 1975 model vehicles.
5. A program of control-device inspection and maintenance, mandatory for all light-duty vehicles.
6. A program of mandatory retro-fitting of pre-1973 heavy-duty gasoline vehicles with evaporative emission and crankcase emission control devices equivalent to those on 1973 and later model vehicles.

It is recognized that this recommendation will be most difficult to implement in practice, because of major obstacles, especially economic ones, and it is not necessarily the opinion of the contractors that this is the most desirable solution to the rather serious problem the Baltimore area faces. The only other available alternatives, however, are outside the scope of the present effort and cannot really be quantitated properly with present information; they are discussed in a general manner in subsection C of this section.

B. IMPACT ON POLLUTANT EMISSIONS

The assessment of the impact of the recommendations on the level of pollutant emissions is a three-step calculation; the percentage estimates of effectiveness are not directly additive, but must be applied to the emissions remaining in each step, as summarized in Table I-2.

Considering the emissions expected in 1977 (after the effect of the federal motor vehicle emission control program has been included) as 100 percent, the first step is to reduce this by the effect of strategies that reduce VMT or increase speeds and hence reduce emissions. The traffic flow improvements are conservatively estimated to reduce the aggregate emissions by 10 percent, primarily by increasing speeds and decreasing idle time. The transit services improvements and the fare elimination are estimated to reduce area-wide VMT by about 2 and 14 percent respectively; they are not completely additive, however, and the combined effect is estimated at 15 percent VMT reduction. Together these three elements of the strategy reduce the emissions (of both pollutants) to 75 percent of the original total.

The second calculation step is to apply the effect of the light-duty retrofit and inspection-maintenance programs to the 75 percent balance. The effect of the catalytic converter retrofit is a reduction of 27.34 percent of the hydrocarbon emissions and 30.52 percent of the CO emissions from the "average" vehicle. This figure has been modified to reflect the effect of vehicles not subject to the program, such as heavy-duty and transient light-duty vehicles. As discussed previously, it is assumed that 95 percent of the light-duty vehicles are effectively controlled. The estimated effectiveness of these programs is of course heavily dependent on the degree of enforcement. The 95% factor used is intended to allow for travel by vehicles registered out of the Baltimore area, primarily out of state; it makes no allowance for less than thorough enforcement. If, as is likely, the enforcement experience indicates that a lower factor would be more accurate, this could be accommodated by increasing the emission reductions gained from heavy-duty vehicles as from non-vehicular sources.

As seen in Table I-2, the accumulated effect of these strategies meets the required reduction in CO emissions in the Central Analysis Area; in fact, as most are uniformly effective, they will affect reductions region-wide. These strategies are not enough, however, to provide the required hydrocarbon reduction, leaving a required further reduction of 2612 kg, or about 8.6 percent of the original expected 1977 total. This latter portion is then gained by the heavy-duty vehicle retrofit program.

C. POSSIBLE ALTERNATIVES

As a careful study of the several tables of emissions indicates, the difficulty in achieving the necessary hydrocarbon emission reduction arises in large part because of the large portions of these emissions constructed by stationary sources and heavy-duty vehicles, neither of which is controlled by most of the measures under consideration in the present study. Thus the major burden of providing the sizable hydrocarbon reduction falls heavily on the light-duty vehicle. It should be noted that because of it's nature as a major port city, Baltimore has greater-than-typical truck traffic, so that that portion of the problem is correspondingly magnified. The principal alternative to the present recommendations would seem to be a greater effort at reducing heavy-duty vehicle emissions through a greater retrofit program. The principal obstacle to planning such a program is the lack of quantitative information on the emissions of retrofitted trucks, and the requirement by EPA that States furnish evidence of effectiveness of such a program.

There is also the alternate possibility of striving for further VMT-reduction-through-transit-use by accelerating plans for the planned rail rapid transit links. Although careful consideration of such possibilities was eliminated from the present study by the Air Quality Task Force, there do seem to be possibilities, particularly when one considers the impact of the subsidized-fare alternative.

VI. SURVEILLANCE AND REVIEW

It is difficult to program a coherent detailed plan for implementing the recommended strategies because of the difficulty in circumventing the obstacles involved. There are, however, a number of events which either are expected to occur and hence inherent in the assumptions herein, or else are necessary for the successful implementation of the recommendations. These are summarized chronologically in Table VI-1, with the most crucial checkpoints marked with an asterisk.

It should be noted that this type of surveillance applies principally to transportation controls. An equally important part of any surveillance process, one which should be the responsibility of all parties, is the continuing reassessment of both the problem itself and the appropriateness of the required controls. As was discussed earlier in this Introduction, the present study employed a whole range, not only of extant data and techniques, but also of assumptions about the course of future events. This data base should be continuously reviewed as new information becomes available. Thus, although the key background parameters are called out in the Surveillance Process, a thorough and continuing review of all the data, techniques and assumptions contained in this report will be required to properly update the problem definition and appropriate control measures. Since the assessment of the air quality data and the pollution problem it implies has been a source of occasional lack of unanimity, Table VI-2 lists a few of the issues of that nature that should be periodically reassessed.

TABLE VI-1

CHECKPOINTS IN TRANSPORTATION PROGRAMS

DATE	PROGRAM
1973	Legislature pass periodic motor vehicle inspection program with provision for inspection and maintenance.
	Final engineering and design on Phase I, Northwest and South lines, rail rapid transit.
	Decisions on proposed highway court cases and review of Environmental Impact Statements.
	MTA purchase of suburban bus companies.
	Probably additional UMTA funding for buses and rapid transit.
	Begin installation of digitized traffic signal control system.

1974	Legislature pass legislation permitting transit fare subsidy.
	Legislature pass legislation authority for retrofit programs.
	Plans for construction of inspection stations.
	Construction of Phase rapid transit commences.
	Completion of I-95 to Eastern Avenue.
	Implementation of traffic surveillance on I-83.

1975-76	Construction of inspection stations in Baltimore area.
	Implementation of transit fare schedule changes.
	Traffic signal control system operational in Baltimore City.

1978	Phase I rapid transit operational.

TABLE VI-2

PROBLEM ASSESSMENT ISSUES

Air Quality Data Availability

1. Data from AIRMON stations during first winter of operation (1972-73).
2. Data from newly-installed oxidant sensors in suburban areas (summer, 1973).

Air Quality Data Validation

1. Continuing integration of MBAQS stations into state-wide data system - should include significant improvement in validation procedures.
2. Completion of AIRMON shake-down and full development of data processing system.

Other Air Quality Data Bases

1. Possible revised oxidant - hydrocarbon relationship based on continuously-expanding non-methane - hydrocarbon data availability.
2. Possible use of AIRMON data to develop a Baltimore-based oxidant - hydrocarbon relationship.

APPENDIX A

VEHICLE MILES OF TRAVEL

APPENDIX A

VEHICLE MILES OF TRAVEL (VMT)

The data contained in the following tables was provided as an input to the emissions model. Total district VMT was estimated by facility type as described in Section II.C of the text. VMT by vehicle type was factored, as described in the text. It should be noted that the estimates for heavy duty vehicles (trucks) and diesel vehicles (non-gasoline) are based on regional and area factors, as real data at the level of detail of individual districts is not available. These figures provide the best estimates of regional travel prorated to a district level for purposes of analysis.

The data are presented for 24-hour, peak-hour, and 12-hour time periods, for 1970 and 1977. The basic data was developed for the two years by the Koppelman procedure, and the various time periods were estimated with factors. Drawing from past engineering studies of traffic volume for 12-hour and peak-hour periods (BMATS, 1962), it was determined that the 24-hour VMT projections for light duty gasoline, heavy duty gasoline, and heavy duty diesel vehicles would be weighted by 10 percent for peak-hour and 75 percent for 12 hour estimates.

Vehicle Miles of Travel (VMT)

Metropolitan Area Baltimore
Year 1970
Time Period Peak Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway		0	0	0	
	Arterial	12	10,608	1,184	143	
	Collector		--	--	--	
	Local	4	1,623	181	22	
	TOTAL	9	12,231	1,365	165	.554
10	Freeway		0	0	0	
	Arterial	17	8,746	976	118	
	Collector		--	--	--	
	Local	8	2,794	312	38	
	TOTAL	14	11,540	1,288	156	1.14
11	Freeway		0	0	0	
	Arterial	23	2,504	280	34	
	Collector		--	--	--	
	Local	11	905	101	12	
	TOTAL	18	3,409	381	46	1.61
12	Freeway	41	7,135	796	96	
	Arterial	22	12,162	1,357	164	
	Collector		--	--	--	
	Local	13	6,068	677	82	
	TOTAL	21	25,365	2,830	342	2.20
13	Freeway	43	3,754	419	51	
	Arterial	23	10,660	1,190	144	
	Collector		--	--	--	
	Local	13	6,007	671	81	
	TOTAL	20	20,421	2,280	276	5.07
20	Freeway		0	0	0	
	Arterial	18	12,067	1,347	163	
	Collector		--	--	--	
	Local	9	4,067	454	55	
	TOTAL	14	16,134	1,801	218	2.17

Baltimore - 1970 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
21	Freeway	42	2,182	244	30	
	Arterial	22	5,457	609	74	
	Collector		--	--	--	
	Local	12	2,713	303	37	
	TOTAL	20	10,352	1,156	141	2.34
22	Freeway		0	0	0	
	Arterial	21	5,102	569	69	
	Collector		--	--	--	
	Local	12	2,236	250	30	
	TOTAL	17	7,338	819	99	2.24
30	Freeway		0	0	0	
	Arterial	18	8,105	905	109	
	Collector		--	--	--	
	Local	8	3,096	346	42	
	TOTAL	13	11,201	1,251	151	1.13
31	Freeway		0	0	0	
	Arterial	19	10,274	1,147	139	
	Collector		--	--	--	
	Local	10	4,560	509	62	
	TOTAL	15	14,834	1,656	201	2.93
32	Freeway		0	0	0	
	Arterial	20	10,142	1,132	137	
	Collector		--	--	--	
	Local	11	4,632	517	63	
	TOTAL	16	14,774	1,649	200	3.91
33	Freeway		0	0	0	
	Arterial	21	14,590	1,628	197	
	Collector		--	--	--	
	Local	11	6,591	736	89	
	TOTAL	17	21,181	2,364	286	5.71
40	Freeway	36	5,312	593	72	
	Arterial	16	14,905	1,663	201	
	Collector		--	--	--	
	Local	7	4,009	447	54	
	TOTAL	15	24,226	2,703	327	1.61

Baltimore - 1970 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
35	Freeway	44	4,670	521	63	
	Arterial	24	10,320	1,152	139	
	Collector		--	--	--	
	Local	13	5,280	589	71	
	TOTAL	22	20,270	2,262	273	6.46
36	Freeway	43	17,358	1,937	234	
	Arterial	23	15,823	1,766	214	
	Collector		--	--	--	
	Local	14	9,230	1,030	125	
	TOTAL	24	42,411	4,733	573	10.1
37	Freeway	45	6,632	740	90	
	Arterial	26	20,168	2,251	272	
	Collector		--	--	--	
	Local	16	10,532	1,176	142	
	TOTAL	24	37,332	4,167	504	20.4
38	Freeway		0	0	0	
	Arterial	34	3,560	397	48	
	Collector		--	--	--	
	Local	19	1,585	177	21	
	TOTAL	27	5,145	574	69	25.3
44	Freeway	43	6,972	778	94	
	Arterial	23	9,421	1,052	127	
	Collector		--	---	--	
	Local	13	4,790	535	65	
	TOTAL	23	21,183	2,365	286	3.63
45	Freeway	44	17,214	1,921	232	
	Arterial	25	13,438	1,500	181	
	Collector		--	--	--	
	Local	15	8,105	905	110	
	TOTAL	26	38,757	4,326	523	8.79
46	Freeway	48	4,749	530	64	
	Arterial	30	16,677	1,861	225	
	Collector		--	--	--	
	Local	18	8,434	941	114	
	TOTAL	26	29,860	3,332	403	27.9

Baltimore - 1970 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
47	Freeway	52	6,479	723	88	
	Arterial	34	8,455	944	114	
	Collector		--	--	--	
	Local	20	4,943	552	67	
	TOTAL	32	19,877	2,219	269	21.3
48	Freeway		0	0	0	
	Arterial	33	10,612	1,184	143	
	Collector		--	--	--	
	Local	20	4,821	538	65	
	TOTAL	27	15,433	1,722	208	43.6
49	Freeway	56	1,473	164	20	
	Arterial	40	2,461	275	33	
	Collector		--	--	--	
	Local	24	1,425	159	19	
	TOTAL	36	5,359	598	72	23.8
54	Freeway	38	471	53	6	
	Arterial	19	18,093	2,019	244	
	Collector		--	--	--	
	Local	10	7,521	840	102	
	TOTAL	16	26,085	2,912	352	6.09
55	Freeway	40	4,213	470	57	
	Arterial	20	11,536	1,288	156	
	Collector		--	--	--	
	Local	11	5,875	656	79	
	TOTAL	18	21,624	2,414	292	3.36
56	Freeway	43	12,103	1,351	163	
	Arterial	24	25,998	2,902	351	
	Collector		--	--	--	
	Local	14	14,195	1,584	192	
	TOTAL	22	52,296	5,837	706	19.3
57	Freeway	44	10,391	1,160	140	
	Arterial	25	12,425	1,387	168	
	Collector		--	--	--	
	Local	14	6,515	727	88	
	TOTAL	25	29,331	3,274	396	11.3

Baltimore - 1970 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
41	Freeway	37	7,358	821	99	
	Arterial	18	14,132	1,577	191	
	Collector		--	--	--	
	Local	10	5,896	658	80	
	TOTAL	17	27,386	3,056	370	2.97
42	Freeway		0	0	0	
	Arterial	18	18,724	2,090	253	
	Collector		--	--	--	
	Local	9	8,572	957	116	
	TOTAL	14	27,296	3,047	369	4.85
43	Freeway	41	11,184	1,248	151	
	Arterial	21	14,800	1,652	200	
	Collector		--	--	--	
	Local	12	7,344	820	99	
	TOTAL	21	33,328	3,720	450	4.95
50	Freeway	35	1,506	168	20	
	Arterial	16	17,956	2,004	242	
	Collector		--	--	--	
	Local	7	4,405	492	60	
	TOTAL	14	23,867	2,664	322	1.87
51	Freeway		0	0	0	
	Arterial	18	17,395	1,942	235	
	Collector		--	--	--	
	Local	9	6,995	781	94	
	TOTAL	14	24,390	2,723	329	2.96
52	Freeway		0	0	0	
	Arterial	20	13,484	1,504	182	
	Collector		--	--	--	
	Local	10	5,854	653	79	
	TOTAL	16	19,338	2,157	261	4.61
53	Freeway		0	0	0	
	Arterial	20	9,776	1,091	132	
	Collector		--	--	--	
	Local	10	4,528	505	61	
	TOTAL	16	14,304	1,596	193	4.01

Baltimore - 1970 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
72	Freeway	42	1,606	179	22	
	Arterial	21	2,589	289	35	
	Collector		--	--	--	
	Local	11	1,424	159	19	
	TOTAL	20	5,619	627	76	1.01
73	Freeway	42	1,282	143	17	
	Arterial	22	4,167	465	56	
	Collector		--	--	--	
	Local	12	1,716	192	23	
	TOTAL	20	7,165	800	96	1.27
74	Freeway	41	2,149	240	29	
	Arterial	22	7,100	792	96	
	Collector		--	--	--	
	Local	12	3,274	365	44	
	TOTAL	19	12,523	1,397	169	2.73
23	Freeway	43	17,766	1,983	240	
	Arterial	24	11,742	1,311	159	
	Collector		--	--	--	
	Local	13	5,838	652	79	
	TOTAL	26	35,346	3,946	478	6.81
24	Freeway	41	6,828	762	92	
	Arterial	21	13,242	1,478	179	
	Collector		--	--	--	
	Local	12	6,458	721	87	
	TOTAL	20	26,528	2,961	358	5.07
25	Freeway	44	1,256	140	17	
	Arterial	24	5,293	591	72	
	Collector		--	--	--	
	Local	15	2,924	326	40	
	TOTAL	21	9,473	1,057	129	6.18
34	Freeway	38	10,341	1,154	140	
	Arterial	18	13,074	1,459	177	
	Collector		--	--	--	
	Local	11	6,660	743	90	
	TOTAL	19	30,075	3,356	407	3.92

Baltimore - 1970 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
60	Freeway		0	0	0	
	Arterial	17	8,182	913	111	
	Collector		--	--	--	
	Local	7	2,515	281	34	
	TOTAL	13	10,697	1,194	145	1.12
61	Freeway		0	0	0	
	Arterial	20	9,630	1,075	130	
	Collector		--	--	--	
	Local	10	3,356	375	45	
	TOTAL	16	12,986	1,450	175	2.21
62	Freeway		0	0	0	
	Arterial	22	8,480	946	115	
	Collector		--	--	--	
	Local	11	3,746	418	51	
	TOTAL	17	12,226	1,364	166	3.57
63	Freeway	40	2,659	297	36	
	Arterial	22	12,789	1,427	173	
	Collector		--	--	--	
	Local	11	4,380	489	59	
	TOTAL	19	19,828	2,213	268	4.54
64	Freeway	37	4,188	467	57	
	Arterial	20	18,468	2,061	249	
	Collector		--	--	--	
	Local	11	6,915	772	93	
	TOTAL	18	29,571	3,300	399	2.64
70	Freeway		0	0	0	
	Arterial	19	4,666	521	63	
	Collector		--	--	--	
	Local	8	1,564	175	21	
	TOTAL	14	6,230	696	84	1.14
71	Freeway	32	2,759	308	37	
	Arterial	14	15,487	1,728	209	
	Collector		--	--	--	
	Local	8	6,213	693	84	
	TOTAL	12	24,459	2,729	330	1.06

Baltimore - 1970 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
58	Freeway	56	1,803	201	24	
	Arterial	39	5,859	654	79	
	Collector		--	--	--	
	Local	23	2,817	314	38	
	TOTAL	35	10,479	1,169	141	56.0
59	Freeway		0	0	0	
	Arterial	37	2,874	321	39	
	Collector		--	--	--	
	Local	21	1,060	118	14	
	TOTAL	31	3,934	439	53	22.4
65	Freeway	44	18,595	2,075	251	
	Arterial	24	11,277	1,259	152	
	Collector		--	--	--	
	Local	14	7,054	787	95	
	TOTAL	27	36,926	4,121	498	8.76
66	Freeway	44	9,592	1,070	130	
	Arterial	25	20,045	2,237	271	
	Collector		---	--	--	
	Local	15	9,919	1,107	134	
	TOTAL	24	39,556	4,414	535	11.1
67	Freeway	50	6,086	679	82	
	Arterial	31	9,960	1,112	135	
	Collector		--	--	--	
	Local	18	5,824	650	79	
	TOTAL	29	21,870	2,441	296	29.2
68	Freeway	50	6,289	702	85	
	Arterial	32	10,678	1,192	144	
	Collector		--	--	--	
	Local	19	5,579	623	75	
	TOTAL	30	22,546	2,517	304	19.8
75	Freeway	43	1,748	195	23	
	Arterial	23	5,936	663	80	
	Collector		--	--	--	
	Local	11	2,698	301	36	
	TOTAL	19	10,382	1,159	139	4.58

Baltimore - 1970 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
76	Freeway		0	0	0	
	Arterial	21	17,615	1,966	238	
	Collector		--	--	--	
	Local	12	7,515	839	101	
	TOTAL	17	25,130	2,805	339	6.24
77	Freeway	44	3,300	368	45	
	Arterial	24	10,475	1,169	141	
	Collector		--	--	--	
	Local	14	5,161	576	70	
	TOTAL	22	18,936	2,113	256	12.0
78	Freeway		0	0	0	
	Arterial	24	11,699	1,306	158	
	Collector		--	--	--	
	Local	14	5,570	622	75	
	TOTAL	20	17,269	1,928	233	11.6
79	Freeway		0	0	0	
	Arterial	30	3,589	401	49	
	Collector		--	--	--	
	Local	16	1,650	184	22	
	TOTAL	23	5,239	585	71	14.4
14	Freeway	43	10,921	1,219	147	
	Arterial	24	28,614	3,194	386	
	Collector		--	--	--	
	Local	15	14,571	1,626	197	
	TOTAL	22	54,106	6,039	730	14.7
15	Freeway		0	0	0	
	Arterial	33	3,289	367	44	
	Collector		--	--	--	
	Local	19	1,531	171	21	
	TOTAL	26	4,820	538	65	12.4
16	Freeway		0	0	0	
	Arterial	21	12,011	1,341	162	
	Collector		--	--	--	
	Local	12	5,474	611	74	
	TOTAL	17	17,485	1,952	236	4.98

Baltimore - 1970 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
17	Freeway		0	0	0	
	Arterial	29	16,262	1,815	220	
	Collector		--	--	--	
	Local	18	9,323	1,041	126	
	TOTAL	23	25,585	2,856	346	35.5
18	Freeway		0	0	0	
	Arterial	28	35,073	3,915	474	
	Collector		--	--	--	
	Local	18	16,493	1,841	223	
	TOTAL	24	51,566	5,756	697	37.0
26	Freeway	45	10,946	1,222	148	
	Arterial	26	14,477	1,616	196	
	Collector		--	--	--	
	Local	16	8,245	920	111	
	TOTAL	26	33,668	3,758	455	11.6
28	Freeway	49	10,351	1,155	140	
	Arterial	31	10,998	1,228	149	
	Collector		--	--	--	
	Local	19	7,128	796	96	
	TOTAL	30	28,477	3,179	385	22.3
27	Freeway		0	0	0	
	Arterial	30	11,167	1,246	151	
	Collector		--	--	--	
	Local	18	5,063	565	68	
	TOTAL	25	16,230	1,811	219	20.5
29	Freeway		0	0	0	
	Arterial	33	29,766	3,322	402	
	Collector		--	--	--	
	Local	20	13,062	1,458	176	
	TOTAL	27	42,828	4,780	578	61.2
39	Freeway	50	5,246	586	70	
	Arterial	32	13,766	1,536	186	
	Collector		--	--	--	
	Local	18	6,742	752	91	
	TOTAL	28	25,754	2,874	347	27.8

Baltimore - 1970 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
	Freeway		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		1,483,390	165,565	20,031	1,668,986
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					

Vehicle Miles of Travel (VMT)

Metropolitan Area Baltimore

Year 1970

Time Period 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway		0	0	0	
	Arterial	12	79,556	8,879	1,074	
	Collector		--	--	--	
	Local	4	12,174	1,358	164	
	TOTAL	9	91,730	10,237	1,238	.554
10	Freeway		0	0	0	
	Arterial	17	65,597	7,321	886	
	Collector		--	--	--	
	Local	8	22,302	2,339	283	
	TOTAL	14	86,549	9,660	1,169	1.14
11	Freeway		0	0	0	
	Arterial	23	18,783	2,096	254	
	Collector		--	--	--	
	Local	11	6,789	758	92	
	TOTAL	18	25,572	2,854	346	1.61
12	Freeway	41	53,514	5,973	722	
	Arterial	22	91,215	10,181	1,232	
	Collector		--	--	--	
	Local	13	45,508	5,079	614	
	TOTAL	21	190,237	21,233	2,568	2.20
13	Freeway	43	28,151	3,142	380	
	Arterial	23	79,948	8,923	1,079	
	Collector		--	--	--	
	Local	13	45,054	5,029	608	
	TOTAL	20	153,153	17,094	2,067	5.07
20	Freeway		0	0	0	
	Arterial	18	90,506	10,102	1,222	
	Collector		--	--	--	
	Local	9	30,499	3,404	412	
	TOTAL	14	121,005	13,506	1,634	2.17

Baltimore - 1970 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
21	Freeway	42	16,366	1,826	221	
	Arterial	22	40,926	4,568	553	
	Collector		--	--	--	
	Local	12	20,345	2,271	275	
	TOTAL	20	77,637	8,665	1,049	2.34
22	Freeway		0	0	0	
	Arterial	21	38,264	4,271	517	
	Collector		--	--	--	
	Local	12	16,769	1,871	227	
	TOTAL	17	55,033	6,142	744	2.24
30	Freeway		0	0	0	
	Arterial	18	60,790	6,785	821	
	Collector		--	--	--	
	Local	8	23,219	2,591	314	
	TOTAL	13	84,009	9,376	1,135	1.13
31	Freeway		0	0	0	
	Arterial	19	77,056	8,600	1,040	
	Collector		--	--	--	
	Local	10	34,197	3,817	462	
	TOTAL	15	111,253	12,417	1,502	2.93
32	Freeway		0	0	0	
	Arterial	20	76,062	8,489	1,027	
	Collector		--	--	--	
	Local	11	34,743	3,878	469	
	TOTAL	16	110,805	12,367	1,496	3.91
33	Freeway		0	0	0	
	Arterial	21	109,424	12,213	1,478	
	Collector		--	--	--	
	Local	11	49,430	5,517	668	
	TOTAL	17	158,854	17,730	2,146	5.71
40	Freeway	36	39,838	4,446	538	
	Arterial	16	111,784	12,476	1,509	
	Collector		--	--	--	
	Local	7	30,065	3,356	406	
	TOTAL	15	181,687	20,278	2,453	1.61

Baltimore - 1970 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
41	Freeway	37	55,188	6,160	744	
	Arterial	18	105,990	11,830	1,431	
	Collector		--	--	--	
	Local	10	44,220	4,936	597	
	TOTAL	17	205,398	22,926	2,772	2.97
42	Freeway		0	0	0	
	Arterial	18	140,429	15,674	1,896	
	Collector		--	--	--	
	Local	9	64,292	7,176	868	
	TOTAL	14	204,721	22,850	2,764	4.85
43	Freeway	41	83,879	9,362	1,133	
	Arterial	21	111,000	12,389	1,499	
	Collector		--	--	--	
	Local	12	55,079	6,147	744	
	TOTAL	21	249,958	27,898	3,376	4.95
50	Freeway	35	11,297	1,261	152	
	Arterial	16	134,672	15,031	1,818	
	Collector		--	--	--	
	Local	7	33,034	3,687	446	
	TOTAL	14	179,003	19,979	2,416	1.87
51	Freeway		0	0	0	
	Arterial	18	130,462	14,561	1,762	
	Collector		--	--	--	
	Local	9	52,460	5,855	708	
	TOTAL	14	182,922	20,416	2,470	2.96
52	Freeway		0	0	0	
	Arterial	20	101,127	11,287	1,365	
	Collector		--	--	--	
	Local	10	43,901	4,900	593	
	TOTAL	16	145,028	16,187	1,958	4.61
53	Freeway		0	0	0	
	Arterial	20	73,320	8,183	990	
	Collector		--	--	--	
	Local	10	33,956	3,789	458	
	TOTAL	16	107,276	11,972	1,448	4.01

Baltimore - 1970 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
60	Freeway		0	0	0	
	Arterial	17	61,362	6,849	829	
	Collector		--	--	--	
	Local	7	18,866	2,105	254	
	TOTAL	13	80,228	8,954	1,083	1.12
61	Freeway		0	0	00	
	Arterial	20	72,225	8,061	975	
	Collector		--	--	--	
	Local	10	25,170	2,810	340	
	TOTAL	16	97,395	10,871	1,315	2.21
62	Freeway		0	0	0	
	Arterial	22	63,597	7,098	859	
	Collector		--	--	--	
	Local	11	28,098	3,136	380	
	TOTAL	17	91,695	10,234	1,239	3.57
63	Freeway	40	19,943	2,226	269	
	Arterial	22	95,917	10,706	1,295	
	Collector		--	--	--	
	Local	11	32,847	3,666	443	
	TOTAL	19	148,707	16,598	2,007	4.54
64	Freeway	37	31,411	3,506	424	
	Arterial	20	138,509	15,456	1,870	
	Collector		--	--	--	
	Local	11	51,864	5,789	701	
	TOTAL	18	221,784	24,751	2,995	2.64
70	Freeway		0	0	0	
	Arterial	19	34,992	3,905	473	
	Collector		--	--	--	
	Local	8	11,726	1,309	158	
	TOTAL	14	46,718	5,214	631	1.14
71	Freeway	32	20,690	2,309	279	
	Arterial	14	116,156	12,964	1,568	
	Collector		--	--	--	
	Local	8	46,598	5,201	629	
	TOTAL	12	183,444	20,474	2,476	1.06

Baltimore - 1970 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
72	Freeway	42	12,047	1,345	163	
	Arterial	21	19,419	2,168	263	
	Collector		--	--	--	
	Local	11	10,683	1,193	144	
	TOTAL	20	42,149	4,706	570	1.01
73	Freeway	42	9,617	1,073	130	
	Arterial	22	31,251	3,488	422	
	Collector		--	--	--	
	Local	12	12,869	1,436	174	
	TOTAL	20	53,737	5,997	726	1.27
74	Freeway	41	16,120	1,799	219	
	Arterial	22	53,249	5,943	719	
	Collector		--	--	--	
	Local	12	24,555	2,741	332	
	TOTAL	19	93,924	10,483	1,270	2.73
23	Freeway	43	133,243	14,871	1,799	
	Arterial	24	88,064	9,829	1,189	
	Collector		--	--	--	
	Local	13	43,781	4,886	591	
	TOTAL	26	265,088	29,586	3,579	6.81
24	Freeway	41	51,209	5,716	692	
	Arterial	21	99,320	11,085	1,341	
	Collector		--	--	--	
	Local	12	48,437	5,406	654	
	TOTAL	20	198,966	22,207	2,687	5.07
25	Freeway	44	9,433	1,053	128	
	Arterial	24	39,700	4,431	536	
	Collector		--	--	--	
	Local	15	21,929	2,447	296	
	TOTAL	21	71,062	7,931	960	6.18
34	Freeway	38	77,555	8,656	1,047	
	Arterial	18	98,058	10,945	1,324	
	Collector		--	--	--	
	Local	11	49,950	5,575	674	
	TOTAL	19	225,563	25,176	3,045	3.92

Baltimore - 1970 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway	44	35,026	3,909	473	
	Arterial	24	77,402	8,639	1,045	
	Collector		--	--	--	
	Local	13	39,597	4,420	535	
	TOTAL	22	152,025	16,968	2,053	6.46
36	Freeway	43	130,184	14,530	1,758	
	Arterial	23	118,669	13,245	1,602	
	Collector		--	--	--	
	Local	14	69,227	7,727	935	
	TOTAL	24	318,080	35,502	4,295	10.1
37	Freeway	45	49,737	5,552	671	
	Arterial	26	151,260	16,883	2,042	
	Collector		--	--	--	
	Local	16	78,991	8,816	1,067	
	TOTAL	24	279,988	31,251	3,780	20.4
38	Freeway		0	0	0	
	Arterial	34	26,699	2,980	361	
	Collector		--	--	--	
	Local	19	11,888	1,327	161	
	TOTAL	27	38,587	4,307	522	25.3
44	Freeway	43	52,288	5,836	706	
	Arterial	23	70,657	7,886	954	
	Collector		--	--	--	
	Local	13	35,923	4,010	485	
	TOTAL	23	158,868	17,732	2,145	3.63
45	Freeway	44	129,108	14,410	1,743	
	Arterial	25	100,784	11,249	1,361	
	Collector		--	--	--	
	Local	15	60,790	6,785	821	
	TOTAL	26	290,682	32,444	3,925	8.79
46	Freeway	48	35,620	3,976	481	
	Arterial	30	125,075	13,960	1,689	
	Collector		--	--	--	
	Local	18	63,252	7,059	854	
	TOTAL	26	223,947	24,995	3,024	27.9

Baltimore - 1970 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
47	Freeway	52	48,589	5,423	656	
	Arterial	34	63,414	7,078	857	
	Collector		--	--	--	
	Local	20	37,071	4,138	500	
	TOTAL	32	149,074	16,639	2,013	21.3
48	Freeway		0	0	0	
	Arterial	33	79,592	8,883	1,075	
	Collector		--	--	--	
	Local	20	36,161	4,036	488	
	TOTAL	27	115,753	12,919	1,563	43.6
49	Freeway	56	11,046	1,233	149	
	Arterial	40	18,455	2,060	249	
	Collector		--	--	--	
	Local	24	10,690	1,193	144	
	TOTAL	36	40,191	4,486	542	23.8
54	Freeway	38	3,533	395	48	
	Arterial	19	135,697	15,146	1,832	
	Collector		--	--	--	
	Local	10	56,410	6,296	761	
	TOTAL	16	195,640	21,837	2,641	6.09
55	Freeway	40	31,595	3,527	427	
	Arterial	20	86,520	9,656	1,169	
	Collector		--	--	--	
	Local	11	44,062	4,918	595	
	TOTAL	18	162,177	18,101	2,191	3.36
56	Freeway	43	90,773	10,131	1,226	
	Arterial	24	194,987	21,763	2,632	
	Collector		--	--	--	
	Local	14	106,459	11,882	1,437	
	TOTAL	22	392,219	43,776	5,295	19.3
57	Freeway	44	77,935	8,699	1,052	
	Arterial	25	93,186	10,400	1,259	
	Collector		--	--	--	
	Local	14	48,865	5,454	660	
	TOTAL	25	219,986	24,553	2,971	11.3

Baltimore - 1970 - 12 Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
58	Freeway	56	13,524	1,510	182	
	Arterial	39	43,940	4,904	593	
	Collector		--	--	--	
	Local	23	21,128	2,358	285	
	TOTAL	35	78,592	8,772	1,060	56.0
59	Freeway		0	0	0	
	Arterial	37	21,552	2,405	291	
	Collector		--	--	--	
	Local	21	1,198	887	107	
	TOTAL	31	29,500	3,292	398	22.4
65	Freeway	44	139,462	15,566	1,883	
	Arterial	24	84,581	9,440	1,142	
	Collector		--	--	--	
	Local	14	52,905	5,905	714	
	TOTAL	27	276,948	30,911	3,739	8.76
66	Freeway	44	71,942	8,029	971	
	Arterial	25	150,335	16,779	2,030	
	Collector		--	--	--	
	Local	15	74,394	8,303	1,004	
	TOTAL	24	296,671	33,111	4,005	11.1
67	Freeway	50	45,648	5,095	617	
	Arterial	31	74,699	8,337	1,009	
	Collector		--	--	--	
	Local	18	43,683	4,876	590	
	TOTAL	29	164,030	18,308	2,216	29.2
68	Freeway	50	47,166	5,264	637	
	Arterial	32	80,087	8,939	1,082	
	Collector		--	--	--	
	Local	19	41,840	4,670	565	
	TOTAL	30	169,093	18,873	2,284	19.8
75	Freeway	43	13,111	1,463	177	
	Arterial	23	44,516	4,969	601	
	Collector		--	--	--	
	Local	11	20,234	2,258	273	
	TOTAL	19	77,861	8,690	1,051	4.58

Baltimore - 1970 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
76	Freeway		0	0	0	
	Arterial	21	132,112	14,745	1,784	
	Collector		--	--	--	
	Local	12	56,365	6,290	761	
	TOTAL	17	188,477	21,035	2,545	6.24
77	Freeway	44	24,748	2,762	335	
	Arterial	24	78,563	8,768	1,060	
	Collector		--	--	--	
	Local	14	38,711	4,321	523	
	TOTAL	22	142,022	15,851	1,918	12.0
78	Freeway		0	0	0	
	Arterial	24	87,742	9,793	1,185	
	Collector		--	--	--	
	Local	14	41,774	4,663	564	
	TOTAL	20	129,516	14,456	1,749	11.6
79	Freeway		0	0	0	
	Arterial	30	26,918	3,005	364	
	Collector		--	--	--	
	Local	16	12,378	1,382	167	
	TOTAL	23	39,296	4,387	531	14.4
14	Freeway	43	81,907	9,142	1,105	
	Arterial	24	214,607	23,953	2,897	
	Collector		--	--	--	
	Local	15	109,282	12,197	1,475	
	TOTAL	22	405,796	45,292	5,477	14.7
15	Freeway		0	0	0	
	Arterial	33	24,667	2,753	333	
	Collector		--	--	--	
	Local	19	11,482	1,282	155	
	TOTAL	26	36,149	4,035	488	12.4
16	Freeway		0	0	0	
	Arterial	21	90,084	10,055	1,216	
	Collector		--	--	--	
	Local	12	41,054	4,582	554	
	TOTAL	17	131,138	14,637	1,770	4.98

Baltimore - 1970 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
17	Freeway		0	0	0	
	Arterial	29	121,962	13,613	1,646	
	Collector		--	--	--	
	Local	18	69,925	7,804	944	
	TOTAL	23	191,887	21,417	2,590	35.5
18	Freeway		0	0	0	
	Arterial	28	263,049	29,360	3,552	
	Collector		--	--	--	
	Local	18	123,695	13,806	1,670	
	TOTAL	24	386,744	43,166	5,222	37.0
26	Freeway	45	82,093	9,163	1,109	
	Arterial	26	108,578	12,119	1,466	
	Collector		--	--	--	
	Local	16	61,838	6,902	835	
	TOTAL	26	252,509	28,184	3,410	11.6
28	Freeway	49	77,636	8,665	1,049	
	Arterial	31	82,485	9,206	1,114	
	Collector		--	--	--	
	Local	19	53,463	5,967	722	
	TOTAL	30	213,584	23,838	2,885	22.3
27	Freeway		0	0	0	
	Arterial	30	83,753	9,348	1,131	
	Collector		--	--	--	
	Local	18	37,973	4,238	513	
	TOTAL	25	121,726	13,586	1,644	20.5
29	Freeway		0	0	0	
	Arterial	33	223,344	24,916	3,014	
	Collector		--	--	--	
	Local	20	97,964	10,934	1,323	
	TOTAL	27	321,208	35,850	4,337	61.2
39	Freeway	50	39,346	4,391	531	
	Arterial	32	103,246	11,523	1,394	
	Collector		--	--	--	
	Local	18	50,561	5,643	683	
	TOTAL	28	193,153	21,557	2,608	27.8

Baltimore - 1970 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
	Freeway		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		11,125,407	1,241,727	150,221	12,517,355
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					

Vehicle Miles of Travel (VMT)

Metropolitan Area Baltimore

Year 1970

Time Period 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway		0	0	0	
	Arterial	12	106,075	11,839	1,432	
	Collector		--	--	--	
	Local	4	16,232	1,811	219	
	TOTAL	9	122,307	13,650	1,651	.554
10	Freeway		0	0	0	
	Arterial	17	87,463	9,761	1,181	
	Collector		--	--	--	
	Local	8	27,936	3,118	377	
	TOTAL	14	115,399	12,879	1,558	1.14
11	Freeway		0	0	0	
	Arterial	23	25,044	2,795	338	
	Collector		--	--	--	
	Local	11	9,052	1,010	122	
	TOTAL	18	34,096	3,805	460	1.61
12	Freeway	41	71,352	7,964	963	
	Arterial	22	121,620	13,574	1,642	
	Collector		--	--	--	
	Local	13	60,677	6,772	819	
	TOTAL	21	253,649	28,310	3,424	2.20
13	Freeway	43	37,535	4,189	506	
	Arterial	23	106,597	11,897	1,439	
	Collector		--	--	--	
	Local	13	60,072	6,705	811	
	TOTAL	20	204,204	22,791	2,756	5.07
20	Freeway		0	0	0	
	Arterial	18	120,674	13,469	1,629	
	Collector		--	--	--	
	Local	9	40,665	4,539	549	
	TOTAL	14	161,339	18,008	2,178	2.17

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
21	Freeway	42	21,821	2,435	295	
	Arterial	22	54,568	6,090	737	
	Collector		--	--	--	
	Local	12	27,126	3,028	366	
	TOTAL	20	103,515	11,553	1,398	2.34
22	Freeway		0	0	0	
	Arterial	21	51,018	5,694	689	
	Collector		--	--	--	
	Local	12	22,358	2,495	302	
	TOTAL	17	73,376	8,189	991	2.24
30	Freeway		0	0	0	
	Arterial	18	81,053	9,046	1,094	
	Collector		--	--	--	
	Local	8	30,958	3,455	418	
	TOTAL	13	112,011	12,501	1,512	1.13
31	Freeway		0	0	0	
	Arterial	19	102,741	11,467	1,387	
	Collector		--	--	--	
	Local	10	45,596	5,089	616	
	TOTAL	15	148,337	16,556	2,003	2.93
32	Freeway		0	0	0	
	Arterial	20	101,416	11,319	1,369	
	Collector		--	--	--	
	Local	11	46,324	5,170	625	
	TOTAL	16	147,740	16,489	1,994	3.91
33	Freeway		0	0	0	
	Arterial	21	145,898	16,284	1,970	
	Collector		--	--	--	
	Local	11	65,907	7,356	890	
	TOTAL	17	211,805	23,640	2,860	5.71
40	Freeway	36	53,117	5,928	717	
	Arterial	16	149,045	16,635	2,012	
	Collector		--	--	--	
	Local	7	40,087	4,474	541	
	TOTAL	15	242,249	27,037	3,270	1.61

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
41	Freeway	37	73,584	8,213	993	
	Arterial	18	141,320	15,773	1,908	
	Collector		--	--	--	
	Local	10	58,960	6,581	796	
	TOTAL	17	273,864	30,567	3,697	2.97
42	Freeway		0	0	0	
	Arterial	18	187,239	20,898	2,528	
	Collector		--	--	--	
	Local	9	85,722	9,568	1,157	
	TOTAL	14	272,961	30,466	3,685	4.85
43	Freeway	41	111,839	12,482	1,510	
	Arterial	21	148,000	16,518	1,998	
	Collector		--	--	--	
	Local	12	73,438	8,196	992	
	TOTAL	21	333,277	37,196	4,500	4.95
50	Freeway	35	15,062	1,681	203	
	Arterial	16	179,562	20,041	2,424	
	Collector		--	--	--	
	Local	7	44,045	4,916	595	
	TOTAL	14	238,669	26,638	3,222	1.87
51	Freeway		0	0	0	
	Arterial	18	173,949	19,415	2,349	
	Collector		--	--	--	
	Local	9	69,947	7,807	944	
	TOTAL	14	243,896	27,222	3,293	2.96
52	Freeway		0	0	0	
	Arterial	20	134,836	15,049	1,820	
	Collector		--	--	--	
	Local	10	58,535	6,533	790	
	TOTAL	16	193,371	21,582	2,610	4.61
53	Freeway		0	0	0	
	Arterial	20	97,760	10,911	1,320	
	Collector		--	--	--	
	Local	10	45,275	5,053	611	
	TOTAL	16	143,035	15,964	1,931	4.01

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
21	Freeway	42	21,821	2,435	295	
	Arterial	22	54,568	6,090	737	
	Collector		--	--	--	
	Local	12	27,126	3,028	366	
	TOTAL	20	103,515	11,553	1,398	2.34
22	Freeway		0	0	0	
	Arterial	21	51,018	5,694	689	
	Collector		--	--	--	
	Local	12	22,358	2,495	302	
	TOTAL	17	73,376	8,189	991	2.24
30	Freeway		0	0	0	
	Arterial	18	81,053	9,046	1,094	
	Collector		--	--	--	
	Local	8	30,958	3,455	418	
	TOTAL	13	112,011	12,501	1,512	1.13
31	Freeway		0	0	0	
	Arterial	19	102,741	11,467	1,387	
	Collector		--	--	--	
	Local	10	45,596	5,089	616	
	TOTAL	15	148,337	16,556	2,003	2.93
32	Freeway		0	0	0	
	Arterial	20	101,416	11,319	1,369	
	Collector		--	--	--	
	Local	11	46,324	5,170	625	
	TOTAL	16	147,740	16,489	1,994	3.91
33	Freeway		0	0	0	
	Arterial	21	145,898	16,284	1,970	
	Collector		--	--	--	
	Local	11	65,907	7,356	890	
	TOTAL	17	211,805	23,640	2,860	5.71
40	Freeway	36	53,117	5,928	717	
	Arterial	16	149,045	16,635	2,012	
	Collector		--	--	--	
	Local	7	40,087	4,474	541	
	TOTAL	15	242,249	27,037	3,270	1.61

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
60	Freeway		0	0	0	
	Arterial	17	81,816	9,132	1,105	
	Collector		--	--	--	
	Local	7	25,154	2,807	339	
	TOTAL	13	106,970	11,939	1,444	1.12
61	Freeway		0	0	0	
	Arterial	20	96,300	10,748	1,300	
	Collector		--	--	--	
	Local	10	33,560	3,746	453	
	TOTAL	16	129,860	14,494	1,753	2.21
62	Freeway		0	0	0	
	Arterial	22	84,796	9,464	1,145	
	Collector		--	--	--	
	Local	11	37,464	4,181	506	
	TOTAL	17	122,260	13,645	1,651	3.57
63	Freeway	40	26,591	2,968	359	
	Arterial	22	127,889	14,274	1,727	
	Collector		--	--	--	
	Local	11	43,796	4,888	591	
	TOTAL	19	198,276	22,130	2,677	4.54
64	Freeway	37	41,881	4,674	565	
	Arterial	20	184,678	20,612	2,493	
	Collector		--	--	--	
	Local	11	69,152	7,718	934	
	TOTAL	18	295,711	33,004	3,992	2.64
70	Freeway		0	0	0	
	Arterial	19	46,656	5,207	630	
	Collector		--	--	---	
	Local	8	15,635	1,745	211	
	TOTAL	14	62,291	6,952	841	1.14
71	Freeway	32	27,587	3,079	372	
	Arterial	14	154,874	17,285	2,091	
	Collector		--	--	--	
	Local	8	62,131	6,934	839	
	TOTAL	12	244,592	27,298	3,302	1.06

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
72	Freeway	42	16,063	1,793	217	
	Arterial	21	25,892	2,890	350	
	Collector		--	--	--	
	Local	11	14,244	1,590	192	
	TOTAL	20	56,199	6,273	759	1.01
73	Freeway	42	12,822	1,431	173	
	Arterial	22	41,668	4,650	563	
	Collector		--	--	--	
	Local	12	17,158	1,915	232	
	TOTAL	20	71,648	7,996	968	1.27
74	Freeway	41	21,493	2,399	290	
	Arterial	22	70,998	7,924	959	
	Collector		--	--	--	
	Local	12	32,740	3,654	442	
	TOTAL	19	125,231	13,977	1,691	2.73
23	Freeway	43	177,657	19,828	2,399	
	Arterial	24	117,419	13,105	1,585	
	Collector		--	--	--	
	Local	13	58,375	6,515	788	
	TOTAL	26	353,451	39,448	4,772	6.81
24	Freeway	41	68,279	7,621	922	
	Arterial	21	132,427	14,780	1,788	
	Collector		--	--	--	
	Local	12	64,583	7,208	872	
	TOTAL	20	265,289	29,609	3,582	5.07
25	Freeway	44	12,577	1,404	170	
	Arterial	24	52,933	5,908	715	
	Collector		--	--	--	
	Local	15	29,238	3,263	395	
	TOTAL	21	94,748	10,575	1,280	6.18
34	Freeway	38	103,406	11,541	1,396	
	Arterial	18	130,744	14,593	1,765	
	Collector		--	--	--	
	Local	11	66,600	7,433	899	
	TOTAL	19	300,750	33,567	4,060	3.92

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway	44	46,701	5,212	631	
	Arterial	24	103,203	11,519	1,393	
	Collector		--	--	--	
	Local	13	52,796	5,893	713	
	TOTAL	22	202,700	22,624	2,737	6.46
36	Freeway	43	173,579	19,373	2,344	
	Arterial	23	158,225	17,660	2,136	
	Collector		--	--	--	
	Local	14	92,303	10,302	1,246	
	TOTAL	24	424,107	47,335	5,726	10.1
37	Freeway	45	66,316	7,402	895	
	Arterial	26	201,680	22,510	2,723	
	Collector		--	--	--	
	Local	16	105,321	11,755	1,422	
	TOTAL	24	373,317	41,667	5,040	20.4
38	Freeway		0	0	0	
	Arterial	34	35,598	3,973	481	
	Collector		--	--	--	
	Local	19	15,851	1,769	214	
	TOTAL	27	51,449	5,742	695	25.3
44	Freeway	43	69,717	7,781	941	
	Arterial	23	94,209	10,515	1,272	
	Collector		--	--	--	
	Local	13	47,897	5,346	647	
	TOTAL	23	211,823	23,642	2,860	3.63
45	Freeway	44	172,144	19,213	2,324	
	Arterial	25	134,379	14,998	1,814	
	Collector		--	--	--	
	Local	15	81,053	9,046	1,094	
	TOTAL	26	387,576	43,257	5,232	8.79
46	Freeway	48	47,493	5,301	641	
	Arterial	30	166,766	18,613	2,252	
	Collector		--	--	--	
	Local	18	84,336	9,412	1,139	
	TOTAL	26	298,595	33,326	4,032	27.9

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
47	Freeway	52	64,785	7,231	875	
	Arterial	34	84,552	9,437	1,142	
	Collector		--	--	--	
	Local	20	49,428	5,517	667	
	TOTAL	32	198,765	22,185	2,684	21.3
48	Freeway		0	0	0	
	Arterial	33	106,122	11,844	1,433	
	Collector		--	--	--	
	Local	20	48,214	5,381	651	
	TOTAL	27	154,336	17,225	2,084	43.6
49	Freeway	56	14,728	1,644	199	
	Arterial	40	24,607	2,746	332	
	Collector		--	--	--	
	Local	24	14,253	1,591	192	
	TOTAL	36	53,588	5,981	723	23.8
54	Freeway	38	4,711	526	64	
	Arterial	19	180,929	20,194	2,442	
	Collector		--	--	--	
	Local	10	75,213	8,395	1,015	
	TOTAL	16	260,853	29,115	3,521	6.09
55	Freeway	40	42,126	4,702	569	
	Arterial	20	115,360	12,875	1,558	
	Collector		--	--	--	
	Local	11	58,749	6,557	793	
	TOTAL	18	216,235	24,134	2,920	3.36
56	Freeway	43	121,031	13,508	1,634	
	Arterial	24	259,983	29,017	3,510	
	Collector		--	--	--	
	Local	14	141,945	15,843	1,916	
	TOTAL	22	522,959	58,368	7,060	19.3
57	Freeway	44	103,913	11,598	1,403	
	Arterial	25	124,248	13,867	1,678	
	Collector		--	--	--	
	Local	14	65,153	7,272	880	
	TOTAL	25	293,314	32,737	3,961	11.3

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
58	Freeway	56	18,032	2,013	243	
	Arterial	39	58,586	6,539	791	
	Collector		--	--	--	
	Local	23	28,170	3,144	380	
	TOTAL	35	104,788	11,696	1,414	56.0
59	Freeway		0	0	0	
	Arterial	37	28,736	3,207	388	
	Collector		--	---	--	
	Local	21	10,597	1,183	143	
	TOTAL	31	39,333	4,390	531	22.4
65	Freeway	44	185,949	20,754	2,511	
	Arterial	24	112,774	12,587	1,523	
	Collector		--	--	--	
	Local	14	70,540	7,873	952	
	TOTAL	27	369,263	41,214	4,986	8.76
66	Freeway	44	95,922	10,705	1,295	
	Arterial	25	200,447	22,372	2,706	
	Collector		--	--	--	
	Local	15	99,192	11,071	1,339	
	TOTAL	24	395,561	44,148	5,340	11.1
67	Freeway	50	60,864	6,793	822	
	Arterial	31	99,599	11,116	1,345	
	Collector		--	--	--	
	Local	18	58,244	6,501	786	
	TOTAL	29	218,707	24,410	2,953	29.2
68	Freeway	50	62,888	7,019	849	
	Arterial	32	106,783	11,918	1,442	
	Collector		--	--	--	
	Local	19	55,787	6,226	753	
	TOTAL	30	225,458	25,163	3,044	19.8
75	Freeway	43	17,481	1,951	236	
	Arterial	23	59,355	6,625	801	
	Collector		--	--	--	
	Local	11	26,979	3,011	364	
	TOTAL	19	103,815	11,587	1,401	4.58

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
76	Freeway		0	0	0	
	Arterial	21	176,149	19,660	2,378	
	Collector		--	--	--	
	Local	12	75,153	8,387	1,014	
	TOTAL	17	251,302	28,047	3,392	6.24
77	Freeway	44	32,997	3,683	446	
	Arterial	24	104,750	11,691	1,414	
	Collector		--	--	--	
	Local	14	51,614	5,761	697	
	TOTAL	22	189,361	21,135	2,557	12.0
78	Freeway		0	0	0	
	Arterial	24	116,989	13,057	1,580	
	Collector		--	--	--	
	Local	14	55,699	6,217	752	
	TOTAL	20	172,688	19,274	2,332	11.6
79	Freeway		0	0	0	
	Arterial	30	35,890	4,006	485	
	Collector		--	--	--	
	Local	16	16,504	1,842	223	
	TOTAL	23	52,394	5,848	708	14.4
14	Freeway	43	109,209	12,189	1,474	
	Arterial	24	286,142	31,937	3,863	
	Collector		--	--	--	
	Local	15	145,709	16,263	1,967	
	TOTAL	22	541,060	60,389	7,304	14.7
15	Freeway		0	0	0	
	Arterial	33	32,889	3,671	444	
	Collector		--	--	--	
	Local	19	15,309	1,709	207	
	TOTAL	26	48,198	5,380	651	12.4
16	Freeway		0	0	0	
	Arterial	21	120,112	13,406	1,621	
	Collector		--	--	--	
	Local	12	54,738	6,109	739	
	TOTAL	17	174,850	19,515	2,360	4.98

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
17	Freeway		0	0	0	
	Arterial	29	162,616	18,150	2,195	
	Collector		--	--	--	
	Local	18	93,233	10,406	1,259	
	TOTAL	23	255,849	28,556	3,454	35.5
18	Freeway		0	0	0	
	Arterial	28	350,732	39,146	4,736	
	Collector		--	--	--	
	Local	18	164,926	18,408	2,227	
	TOTAL	24	515,658	57,554	6,963	37.0
26	Freeway	45	109,457	12,217	1,478	
	Arterial	26	144,770	16,158	1,955	
	Collector		--	--	--	
	Local	16	82,451	9,202	1,113	
	TOTAL	26	336,678	37,577	4,546	11.6
28	Freeway	49	103,514	11,553	1,398	
	Arterial	31	109,980	12,275	1,485	
	Collector		--	--	--	
	Local	19	71,284	7,956	962	
	TOTAL	30	284,778	31,784	3,845	22.3
27	Freeway		0	0	0	
	Arterial	30	111,671	12,464	1,508	
	Collector		--	--	--	
	Local	18	50,630	5,651	684	
	TOTAL	25	162,301	18,115	2,192	20.5
29	Freeway		0	0	0	
	Arterial	33	297,658	33,221	4,019	
	Collector		--	--	--	
	Local	20	130,619	14,579	1,764	
	TOTAL	27	428,277	47,800	5,783	61.2
39	Freeway	50	52,461	5,855	708	
	Arterial	32	137,661	15,364	1,859	
	Collector		--	--	--	
	Local	18	67,415	7,524	910	
	TOTAL	28	257,537	28,743	3,477	27.8

Baltimore - 1970 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
	Freeway		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		14,833,849	1,655,613	200,273	16,689,735
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					

Vehicle Miles of Travel (VMT)
Metropolitan Area Baltimore
Year 1977
Time Period Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway	30	1,815	264	32	
	Arterial	10	13,705	1,992	241	
	Collector		-	-	-	
	Local	3	2,479	360	44	
	TOTAL	8	17,999	2,616	317	.554
10	Freeway		0	0	0	
	Arterial	16	10,225	1,486	180	
	Collector		-	-	-	
	Local	7	3,266	475	57	
	TOTAL	13	13,491	1,961	237	1.14
11	Freeway		0	0	0	
	Arterial	23	2,696	392	47	
	Collector		-	-	-	
	Local	11	974	142	17	
	TOTAL	18	3,670	534	64	1.61
12	Freeway	40	7,045	1,024	124	
	Arterial	20	12,009	1,746	211	
	Collector		-	-	-	
	Local	12	6,021	875	106	
	TOTAL	20	25,075	3,645	441	2.20
13	Freeway	42	6,563	954	115	
	Arterial	22	10,976	1,596	193	
	Collector		-	-	-	
	Local	13	7,127	1,036	125	
	TOTAL	20	24,666	3,586	433	5.07
20	Freeway	36	1,456	212	26	
	Arterial	18	12,853	1,868	226	
	Collector		-	-	-	
	Local	9	4,247	617	75	
	TOTAL	15	18,556	2,697	327	2.17

Baltimore - 1977 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
21	Freeway	42	5,489	798	96	
	Arterial	23	4,837	703	85	
	Collector		-	-	-	
	Local	12	2,299	334	40	
	TOTAL	24	12,625	1,835	221	2.34
22	Freeway	42	5,484	797	96	
	Arterial	22	3,722	541	65	
	Collector		-	-	-	
	Local	12	1,569	228	28	
	TOTAL	25	10,775	1,566	189	2.24
30	Freeway		0	0	0	
	Arterial	17	8,579	1,247	151	
	Collector		-	-	-	
	Local	8	3,277	476	58	
	TOTAL	13	11,856	1,723	209	1.13
31	Freeway		0	0	0	
	Arterial	19	10,639	1,547	187	
	Collector		-	-	-	
	Local	9	4,722	686	83	
	TOTAL	14	15,361	2,233	270	2.93
32	Freeway	40	1,501	218	26	
	Arterial	20	10,604	1,541	186	
	Collector		-	-	-	
	Local	11	5,396	784	95	
	TOTAL	16	17,501	2,543	307	3.91
33	Freeway	41	3,380	491	59	
	Arterial	21	13,210	1,920	232	
	Collector		-	-	-	
	Local	11	6,267	911	110	
	TOTAL	18	22,857	3,322	401	5.71
40	Freeway	35	5,616	816	99	
	Arterial	16	15,718	2,285	276	
	Collector		-	-	-	
	Local	7	4,218	613	74	
	TOTAL	15	25,552	3,714	449	1.61

Baltimore - 1977 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
41	Freeway	36	7,683	1,117	135	
	Arterial	17	15,098	2,195	265	
	Collector		-	-	-	
	Local	9	6,473	941	114	
	TOTAL	16	29,254	4,253	514	2.97
42	Freeway		0	0	0	
	Arterial	17	19,179	2,788	337	
	Collector		-	-	-	
	Local	9	8,780	1,276	154	
	TOTAL	14	27,959	4,064	491	4.85
43	Freeway	39	12,504	1,818	220	
	Arterial	20	16,484	2,396	290	
	Collector		-	-	-	
	Local	12	8,152	1,185	143	
	TOTAL	20	37,140	5,399	653	4.95
50	Freeway	37	2,943	428	52	
	Arterial	17	14,402	2,094	253	
	Collector		-	-	-	
	Local	8	3,466	504	61	
	TOTAL	15	20,811	3,026	366	1.87
51	Freeway		0	0	0	
	Arterial	17	17,949	2,609	315	
	Collector		-	-	-	
	Local	9	7,217	1,049	127	
	TOTAL	14	25,166	3,658	442	2.96
52	Freeway		0	0	0	
	Arterial	20	14,072	2,046	247	
	Collector		-	-	-	
	Local	10	6,109	888	107	
	TOTAL	16	20,181	2,934	354	4.61
53	Freeway		0	0	0	
	Arterial	19	10,974	1,595	193	
	Collector		-	-	-	
	Local	10	5,082	739	89	
	TOTAL	15	16,056	2,334	282	4.01

Baltimore - 1977 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
60	Freeway		0	0	0	
	Arterial	17	8,725	1,268	153	
	Collector		-	-	-	
	Local	7	2,682	390	47	
	TOTAL	13	11,407	1,658	200	1.12
61	Freeway		0	0	0	
	Arterial	20	9,991	1,452	175	
	Collector		-	-	-	
	Local	10	3,482	506	61	
	TOTAL	16	13,473	1,958	236	2.21
62	Freeway		0	0	0	
	Arterial	22	9,393	1,365	165	
	Collector		-	-	-	
	Local	11	4,150	603	73	
	TOTAL	17	13,543	1,968	238	3.57
63	Freeway	40	5,197	755	91	
	Arterial	21	12,699	1,846	223	
	Collector		-	-	-	
	Local	11	4,286	623	75	
	TOTAL	20	22,182	3,224	389	4.54
64	Freeway	38	14,121	2,053	248	
	Arterial	20	15,417	2,241	271	
	Collector		-	-	-	
	Local	11	4,944	719	87	
	TOTAL	19	34,482	5,013	606	2.64
70	Freeway		0	0	0	
	Arterial	18	5,384	783	95	
	Collector		-	-	-	
	Local	8	1,804	262	32	
	TOTAL	14	7,188	1,045	127	1.14
71	Freeway	31	2,812	409	49	
	Arterial	13	15,759	2,291	277	
	Collector		-	-	-	
	Local	8	6,313	918	111	
	TOTAL	12	24,884	3,618	437	1.06

Baltimore - 1977 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
72	Freeway	40	1,988	289	35	
	Arterial	19	3,198	465	56	
	Collector		-	-	-	
	Local	10	1,851	269	33	
	TOTAL	18	7,037	1,023	124	1.01
73	Freeway	43	5,518	802	97	
	Arterial	22	3,807	554	67	
	Collector		-	-	-	
	Local	12	1,092	159	19	
	TOTAL	26	10,417	1,515	183	1.27
74	Freeway	40	2,273	330	40	
	Arterial	21	7,664	1,114	135	
	Collector		-	-	-	
	Local	11	3,613	525	63	
	TOTAL	18	13,550	1,969	238	2.73
23	Freeway	43	22,388	3,255	393	
	Arterial	23	11,245	1,635	198	
	Collector		-	-	-	
	Local	13	5,353	778	94	
	TOTAL	28	38,986	5,668	685	6.81
24	Freeway	42	15,126	2,199	266	
	Arterial	22	10,918	1,587	192	
	Collector		-	-	-	
	Local	12	5,215	758	92	
	TOTAL	24	31,259	4,544	550	5.07
25	Freeway	43	3,034	441	53	
	Arterial	23	6,162	896	108	
	Collector		-	-	-	
	Local	14	3,672	534	65	
	TOTAL	22	12,868	1,871	226	6.18
34	Freeway	38	16,917	2,459	297	
	Arterial	18	12,367	1,798	217	
	Collector		-	-	-	
	Local	10	6,384	928	112	
	TOTAL	20	35,668	5,185	626	3.92

Baltimore - 1977 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway	44	8,433	1,226	148	
	Arterial	25	8,722	1,268	153	
	Collector		-	-	-	
	Local	13	4,491	653	79	
	TOTAL	25	21,646	3,147	380	6.46
36	Freeway	41	18,232	2,650	320	
	Arterial	22	17,899	2,602	314	
	Collector		-	-	-	
	Local	13	10,390	1,510	183	
	TOTAL	23	46,521	6,762	817	10.1
37	Freeway	44	13,793	2,005	242	
	Arterial	25	21,226	3,086	373	
	Collector		-	-	-	
	Local	15	11,864	1,725	208	
	TOTAL	24	46,883	6,816	823	20.4
38	Freeway		0	0	0	
	Arterial	32	9,678	1,407	170	
	Collector		-	-	-	
	Local	20	4,650	676	82	
	TOTAL	27	14,329	2,083	252	25.3
44	Freeway	43	7,302	1,061	128	
	Arterial	23	9,049	1,315	159	
	Collector		-	-	-	
	Local	13	4,588	667	81	
	TOTAL	23	20,939	3,043	368	3.63
45	Freeway	43	16,822	2,445	295	
	Arterial	24	13,238	1,924	233	
	Collector		-	-	-	
	Local	14	7,981	1,160	140	
	TOTAL	25	38,041	5,529	668	8.79
46	Freeway	46	8,606	1,251	151	
	Arterial	27	20,712	3,011	364	
	Collector		-	-	-	
	Local	17	11,170	1,624	196	
	TOTAL	25	40,488	5,886	711	27.9

Baltimore - 1977 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
47	Freeway	50	6,963	1,012	122	
	Arterial	32	9,248	1,344	162	
	Collector		-	-	-	
	Local	19	5,540	805	97	
	TOTAL	30	21,751	3,161	381	21.3
48	Freeway		0	0	0	
	Arterial	31	15,378	2,235	270	
	Collector		-	-	-	
	Local	19	7,252	1,054	127	
	TOTAL	26	22,630	3,289	397	43.6
49	Freeway	54	2,206	321	39	
	Arterial	36	4,115	598	72	
	Collector		-	-	-	
	Local	22	2,569	373	45	
	TOTAL	33	8,890	1,292	156	23.8
54	Freeway	38	478	70	8	
	Arterial	19	18,365	2,670	323	
	Collector		-	-	-	
	Local	10	7,634	1,110	134	
	TOTAL	15	26,477	3,850	465	6.09
55	Freeway	40	3,935	572	69	
	Arterial	20	10,785	1,568	189	
	Collector		-	-	-	
	Local	11	5,497	799	97	
	TOTAL	18	20,217	2,939	355	3.36
56	Freeway	43	12,035	1,749	211	
	Arterial	23	26,161	3,803	459	
	Collector		-	-	-	
	Local	14	14,354	2,087	252	
	TOTAL	22	52,550	7,639	922	19.3
57	Freeway	43	11,423	1,661	201	
	Arterial	23	14,283	2,076	251	
	Collector		-	-	-	
	Local	14	7,779	1,131	137	
	TOTAL	23	33,485	4,868	589	11.3

Baltimore - 1977 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
58	Freeway	55	2,043	297	36	
	Arterial	38	7,056	1,026	124	
	Collector		-	-	-	
	Local	23	3,514	511	62	
	TOTAL	33	12,613	1,834	222	56.0
59	Freeway		0	0	0	
	Arterial	35	4,916	715	86	
	Collector		-	-	-	
	Local	20	1,953	284	34	
	TOTAL	29	6,869	999	120	22.4
65	Freeway	44	18,242	2,652	320	
	Arterial	24	11,175	1,625	196	
	Collector		-	-	-	
	Local	14	6,989	1,016	123	
	TOTAL	26	36,406	5,293	639	8.76
66	Freeway	42	15,460	2,247	272	
	Arterial	23	22,684	3,298	398	
	Collector		-	-	-	
	Local	13	11,939	1,736	210	
	TOTAL	22	50,083	7,281	880	11.1
67	Freeway	48	7,121	1,035	125	
	Arterial	29	13,359	1,942	235	
	Collector		-	-	-	
	Local	18	7,891	1,147	139	
	TOTAL	27	28,371	4,124	499	29.2
68	Freeway	47	7,520	1,093	132	
	Arterial	29	13,761	2,000	242	
	Collector		-	-	-	
	Local	17	7,550	1,097	133	
	TOTAL	27	28,831	4,190	507	19.8
75	Freeway	44	2,579	375	45	
	Arterial	24	4,067	591	71	
	Collector		-	-	-	
	Local	12	1,968	286	35	
	TOTAL	22	8,614	1,252	151	4.58

Baltimore - 1977 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
76	Freeway	41	6,282	913	110	
	Arterial	22	13,094	1,903	230	
	Collector		-	-	-	
	Local	12	5,838	849	103	
	TOTAL	21	25,214	3,665	443	6.24
77	Freeway	44	10,398	1,512	183	
	Arterial	24	9,970	1,449	175	
	Collector		-	-	-	
	Local	14	5,590	813	98	
	TOTAL	24	25,958	3,774	456	12.0
78	Freeway	45	3,705	539	65	
	Arterial	25	10,088	1,466	177	
	Collector		-	-	-	
	Local	14	5,536	805	97	
	TOTAL	22	19,329	2,810	339	11.6
79	Freeway		0	0	0	
	Arterial	28	5,847	850	103	
	Collector		-	-	-	
	Local	16	2,689	391	47	
	TOTAL	23	8,536	1,241	150	14.4
14	Freeway	43	12,325	1,792	216	
	Arterial	23	28,449	4,136	500	
	Collector		-	-	-	
	Local	14	15,009	2,182	264	
	TOTAL	22	55,783	8,110	980	14.7
15	Freeway		0	0	0	
	Arterial	28	7,825	1,138	137	
	Collector		-	-	-	
	Local	17	3,642	529	64	
	TOTAL	23	11,467	1,667	201	12.4
16	Freeway		0	0	0	
	Arterial	20	13,213	1,921	232	
	Collector		-	-	-	
	Local	11	6,021	875	106	
	TOTAL	16	19,234	2,796	338	4.98

Baltimore - 1977 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
17	Freeway		0	0	0	
	Arterial	26	25,091	3,647	441	
	Collector		--	--	--	
	Local	16	13,470	1,958	237	
	TOTAL	22	38,561	5,605	678	35.5
18	Freeway		0	0	0	
	Arterial	26	43,292	6,293	760	
	Collector		--	--	--	
	Local	16	20,423	2,969	359	
	TOTAL	22	63,715	9,262	1,119	37.0
26	Freeway	44	12,480	1,814	219	
	Arterial	25	14,412	2,095	253	
	Collector		--	--	--	
	Local	15	8,365	1,216	147	
	TOTAL	25	35,257	5,125	619	11.6
28	Freeway	47	12,105	1,760	213	
	Arterial	27	14,803	2,152	260	
	Collector		--	--	--	
	Local	17	9,413	1,368	165	
	TOTAL	27	36,321	5,280	638	22.3
27	Freeway	47	21,007	3,054	369	
	Arterial	28	9,634	1,400	169	
	Collector		--	--	--	
	Local	16	5,520	802	97	
	TOTAL	32	36,161	5,256	635	20.5
29	Freeway	48	28,817	4,189	506	
	Arterial	31	28,292	4,113	497	
	Collector		--	--	--	
	Local	18	13,022	1,893	229	
	TOTAL	31	70,131	10,195	1,232	61.2
39	Freeway	49	8,390	1,220	147	
	Arterial	30	17,825	2,591	313	
	Collector		--	--	--	
	Local	17	9,012	1,310	158	
	TOTAL	27	35,227	5,121	618	27.8

Baltimore - 1977 - Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
	Freeway		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		1,741,023	253,086	30,580	2,024,689
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					

Vehicle Miles of Travel (VMT)

Metropolitan Area Baltimore

Year 1977

Time Period 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway	30	13,612	1,979	239	
	Arterial	10	102,785	14,942	1,805	
	Collector		-	-	-	
	Local	3	18,596	2,703	326	
	TOTAL	8	134,993	19,624	2,370	.554
10	Freeway		0	0	0	
	Arterial	16	76,688	11,148	1,347	
	Collector		-	-	-	
	Local	7	24,494	3,561	430	
	TOTAL	13	101,182	14,709	1,777	1.14
11	Freeway		0	0	0	
	Arterial	23	20,218	2,939	355	
	Collector		-	-	-	
	Local	11	7,308	1,062	128	
	TOTAL	18	27,526	4,001	483	1.61
12	Freeway	40	52,838	7,681	928	
	Arterial	20	90,070	13,093	1,582	
	Collector		-	-	-	
	Local	12	45,160	6,565	793	
	TOTAL	20	188,068	27,339	3,303	2.20
13	Freeway	42	49,220	7,155	864	
	Arterial	22	82,322	11,967	1,445	
	Collector		-	-	-	
	Local	13	53,456	7,771	939	
	TOTAL	20	184,998	26,893	3,248	5.07
20	Freeway	36	10,923	1,588	192	
	Arterial	18	96,397	14,013	1,693	
	Collector		-	-	-	
	Local	9	31,850	4,630	560	
	TOTAL	15	139,170	20,231	2,445	2.17

Baltimore - 1977 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
21	Freeway	42	41,169	5,984	723	
	Arterial	23	36,276	5,273	637	
	Collector		-	-	-	
	Local	12	17,245	2,507	303	
	TOTAL	24	94,690	13,764	1,663	2.34
22	Freeway	42	41,133	5,979	722	
	Arterial	22	27,914	4,058	491	
	Collector		-	-	-	
	Local	12	11,764	1,710	206	
	TOTAL	25	80,811	11,747	1,419	2.24
30	Freeway		0	0	0	
	Arterial	17	64,340	9,353	1,130	
	Collector		-	-	-	
	Local	8	24,575	3,572	431	
	TOTAL	13	88,915	12,925	1,561	1.13
31	Freeway		0	0	0	
	Arterial	19	79,794	11,600	1,401	
	Collector		-	-	-	
	Local	9	35,412	5,148	622	
	TOTAL	14	115,206	16,748	2,023	2.93
32	Freeway	40	11,254	1,636	197	
	Arterial	20	79,528	11,561	1,397	
	Collector		-	-	-	
	Local	11	40,470	5,883	711	
	TOTAL	16	131,252	19,080	2,305	3.91
33	Freeway	41	25,352	3,686	446	
	Arterial	21	99,075	14,402	1,740	
	Collector		-	-	-	
	Local	11	47,000	6,833	825	
	TOTAL	18	171,427	24,921	3,011	5.71
40	Freeway	35	42,120	6,123	740	
	Arterial	16	117,882	17,136	2,070	
	Collector		-	-	-	
	Local	7	31,634	4,598	556	
	TOTAL	15	191,636	27,857	3,366	1.61

Baltimore - 1977 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
41	Freeway	36	57,623	8,377	1,012	
	Arterial	17	113,232	16,460	1,988	
	Collector		-	-	-	
	Local	9	48,544	7,056	853	
	TOTAL	16	219,399	31,893	3,853	2.97
42	Freeway		0	0	0	
	Arterial	17	143,842	20,910	2,526	
	Collector		-	-	-	
	Local	9	65,853	9,573	1,157	
	TOTAL	14	209,695	30,483	3,683	4.85
43	Freeway	39	93,776	13,632	1,647	
	Arterial	20	123,629	17,972	2,171	
	Collector		-	-	-	
	Local	12	61,140	8,888	1,074	
	TOTAL	20	278,545	40,492	4,892	4.95
50	Freeway	37	22,070	3,209	388	
	Arterial	17	108,016	15,702	1,897	
	Collector		-	-	-	
	Local	8	25,997	3,779	457	
	TOTAL	15	156,083	22,690	2,742	1.87
51	Freeway		0	0	0	
	Arterial	17	134,615	19,568	2,364	
	Collector		-	-	-	
	Local	9	54,131	7,869	950	
	TOTAL	14	188,746	27,437	3,314	2.96
52	Freeway		0	0	0	
	Arterial	20	105,539	15,342	1,853	
	Collector		-	-	-	
	Local	10	45,816	6,660	805	
	TOTAL	16	151,355	22,002	2,658	4.61
53	Freeway		0	0	0	
	Arterial	19	82,304	11,964	1,445	
	Collector		-	-	-	
	Local	10	38,118	5,541	669	
	TOTAL	15	120,422	17,505	2,114	4.01

Baltimore - 1977 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
60	Freeway		0	0	0	
	Arterial	17	65, 435	9, 512	1, 149	
	Collector		-	-	-	
	Local	7	20, 118	2, 924	353	
	TOTAL	13	85, 553	12, 436	1, 502	1. 12
61	Freeway		0	0	0	
	Arterial	20	74, 935	10, 893	1, 316	
	Collector		-	-	-	
	Local	10	26, 114	3, 797	459	
	TOTAL	16	101, 049	14, 690	1, 775	2. 21
62	Freeway		0	0	0	
	Arterial	22	70, 447	10, 241	1, 237	
	Collector		-	-	-	
	Local	11	31, 124	4, 525	547	
	TOTAL	17	101, 571	14, 766	1, 784	3. 57
63	Freeway	40	38, 976	5, 666	685	
	Arterial	21	95, 240	13, 845	1, 673	
	Collector		-	-	-	
	Local	11	32, 143	4, 673	565	
	TOTAL	20	166, 359	24, 184	2, 923	4. 54
64	Freeway	38	105, 909	15, 395	1, 860	
	Arterial	20	115, 625	16, 808	2, 030	
	Collector		-	-	-	
	Local	11	37, 079	5, 390	651	
	TOTAL	19	258, 613	37, 593	4, 541	2. 64
70	Freeway		0	0	0	
	Arterial	18	40, 381	5, 870	709	
	Collector		-	-	-	
	Local	8	13, 533	1, 967	238	
	TOTAL	14	53, 914	7, 837	947	1. 14
71	Freeway	31	21, 088	3, 065	371	
	Arterial	13	118, 194	17, 182	2, 075	
	Collector		-	-	-	
	Local	8	47, 348	6, 883	832	
	TOTAL	12	186, 630	27, 130	3, 278	1. 06

Baltimore - 1977 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
72	Freeway	40	14,908	2,167	261	
	Arterial	19	23,982	3,486	422	
	Collector		-	-	-	
	Local	10	13,883	2,018	244	
	TOTAL	18	52,773	7,671	927	1.01
73	Freeway	43	41,386	6,016	727	
	Arterial	22	28,555	4,151	502	
	Collector		-	-	-	
	Local	12	8,193	1,191	144	
	TOTAL	26	78,134	11,358	1,373	1.27
74	Freeway	40	17,045	2,478	299	
	Arterial	21	57,481	8,356	1,010	
	Collector		-	-	-	
	Local	11	27,095	3,939	476	
	TOTAL	18	101,621	14,773	1,785	2.73
23	Freeway	43	167,911	24,409	2,948	
	Arterial	23	84,338	12,260	1,481	
	Collector		-	-	-	
	Local	13	40,147	5,836	705	
	TOTAL	28	292,396	42,505	5,134	6.81
24	Freeway	42	113,445	16,491	1,992	
	Arterial	22	81,883	11,903	1,438	
	Collector		-	-	-	
	Local	12	39,112	5,686	687	
	TOTAL	24	234,440	34,080	4,117	5.07
25	Freeway	43	22,754	3,308	400	
	Arterial	23	46,214	6,718	812	
	Collector		-	-	-	
	Local	14	27,539	4,004	484	
	TOTAL	22	96,507	14,030	1,696	6.18
34	Freeway	38	126,876	18,443	2,228	
	Arterial	18	92,752	13,483	1,629	
	Collector		-	-	-	
	Local	10	47,877	6,960	841	
	TOTAL	20	267,505	38,886	4,698	3.92

Baltimore - 1977 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway	44	63,245	9,194	1,111	
	Arterial	25	65,415	9,509	1,149	
	Collector		-	-	-	
	Local	13	33,680	4,896	592	
	TOTAL	25	162,340	23,599	2,852	6.46
36	Freeway	41	136,741	19,877	2,402	
	Arterial	22	134,242	19,514	2,357	
	Collector		-	-	-	
	Local	13	77,927	11,328	1,369	
	TOTAL	23	348,910	50,719	6,128	10.1
37	Freeway	44	103,445	15,038	1,817	
	Arterial	25	159,196	23,141	2,795	
	Collector		-	-	-	
	Local	15	88,976	12,935	1,562	
	TOTAL	24	351,617	51,114	6,174	20.4
38	Freeway		0	0	0	
	Arterial	32	72,588	10,552	1,275	
	Collector		-	-	-	
	Local	20	34,878	5,070	613	
	TOTAL	27	107,466	15,622	1,888	25.3
44	Freeway	43	54,763	7,961	962	
	Arterial	23	67,866	9,866	1,192	
	Collector		-	-	-	
	Local	13	34,411	5,003	605	
	TOTAL	23	157,040	22,830	2,759	3.63
45	Freeway	43	126,167	18,341	2,216	
	Arterial	24	99,286	14,433	1,744	
	Collector		-	-	-	
	Local	14	59,860	8,702	1,052	
	TOTAL	25	285,313	41,476	5,012	8.79
46	Freeway	46	64,544	9,383	1,133	
	Arterial	27	155,342	22,582	2,728	
	Collector		-	-	-	
	Local	17	83,773	12,178	1,471	
	TOTAL	25	303,659	44,143	5,332	27.9

Baltimore - 1977 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
47	Freeway	50	52,220	7,591	917	
	Arterial	32	69,356	10,082	1,218	
	Collector		-	-	-	
	Local	19	41,548	6,040	730	
	TOTAL	30	163,124	23,713	2,865	21.3
48	Freeway		0	0	0	
	Arterial	31	115,334	16,766	2,025	
	Collector		-	-	-	
	Local	19	54,390	7,907	955	
	TOTAL	26	169,724	24,673	2,980	43.6
49	Freeway	54	16,544	2,405	290	
	Arterial	36	30,863	4,487	542	
	Collector		-	-	-	
	Local	22	19,266	2,801	338	
	TOTAL	33	66,673	9,692	1,170	23.8
54	Freeway	38	3,587	521	63	
	Arterial	19	137,735	20,022	2,419	
	Collector		-	-	-	
	Local	10	57,253	8,323	1,005	
	TOTAL	15	198,575	28,866	3,487	6.09
55	Freeway	40	29,511	4,290	518	
	Arterial	20	80,890	11,759	1,421	
	Collector		-	-	-	
	Local	11	41,227	5,994	724	
	TOTAL	18	151,628	22,043	2,663	3.36
56	Freeway	43	90,260	13,121	1,585	
	Arterial	23	196,205	28,522	3,446	
	Collector		-	-	-	
	Local	14	107,658	15,650	1,891	
	TOTAL	22	394,123	57,293	6,922	19.3
57	Freeway	43	85,670	12,454	1,505	
	Arterial	23	107,126	15,572	1,881	
	Collector		-	-	-	
	Local	14	58,340	8,481	1,025	
	TOTAL	23	251,136	36,507	4,411	11.3

Baltimore - 1977 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
58	Freeway	55	15,321	2,228	269	
	Arterial	38	52,922	7,693	929	
	Collector		-	-	-	
	Local	23	26,357	3,831	463	
	TOTAL	33	94,600	13,752	1,661	56.0
59	Freeway		0	0	0	
	Arterial	35	36,872	5,360	647	
	Collector		-	-	-	
	Local	20	14,648	2,129	257	
	TOTAL	29	51,520	7,489	904	22.4
65	Freeway	44	136,817	19,889	2,402	
	Arterial	24	83,816	12,184	1,472	
	Collector		-	-	-	
	Local	14	52,418	7,620	920	
	TOTAL	26	273,051	39,693	4,794	8.76
66	Freeway	42	115,952	16,856	2,036	
	Arterial	23	170,131	24,731	2,987	
	Collector		-	-	-	
	Local	13	89,544	13,017	1,573	
	TOTAL	22	375,627	54,604	6,596	11.1
67	Freeway	48	53,406	7,763	938	
	Arterial	29	100,194	14,565	1,760	
	Collector		-	-	-	
	Local	18	59,184	8,603	1,040	
	TOTAL	27	212,784	30,931	3,738	29.2
68	Freeway	47	56,396	8,198	990	
	Arterial	29	103,203	15,002	1,812	
	Collector		-	-	-	
	Local	17	56,621	8,231	995	
	TOTAL	27	216,220	31,431	3,797	19.8
75	Freeway	44	19,346	2,813	340	
	Arterial	24	30,503	4,434	536	
	Collector		-	-	-	
	Local	12	14,760	2,146	260	
	TOTAL	22	64,609	9,393	1,136	4.58

Baltimore - 1977 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
76	Freeway	41	47,116	6,849	827	
	Arterial	22	98,202	14,276	1,724	
	Collector		-	-	-	
	Local	12	43,785	6,365	769	
	TOTAL	21	189,103	27,490	3,320	6.24
77	Freeway	44	77,987	11,337	1,370	
	Arterial	24	74,776	10,870	1,313	
	Collector		-	-	-	
	Local	14	41,927	6,095	737	
	TOTAL	24	194,690	28,302	3,420	12.0
78	Freeway	45	27,788	4,040	488	
	Arterial	25	75,658	10,998	1,328	
	Collector		-	-	-	
	Local	14	41,519	6,035	729	
	TOTAL	22	144,965	21,073	2,545	11.6
79	Freeway		0	0	0	
	Arterial	28	43,850	6,374	770	
	Collector		-	-	-	
	Local	16	20,165	2,931	354	
	TOTAL	23	64,015	9,305	1,124	14.4
14	Freeway	43	92,440	13,438	1,623	
	Arterial	23	213,366	31,016	3,747	
	Collector		-	-	-	
	Local	14	112,571	16,364	1,977	
	TOTAL	22	418,377	60,818	7,347	14.7
15	Freeway		0	0	0	
	Arterial	28	58,686	8,531	1,031	
	Collector		-	-	-	
	Local	17	27,316	3,971	480	
	TOTAL	23	86,002	12,502	1,511	12.4
16	Freeway		0	0	0	
	Arterial	20	99,096	14,405	1,740	
	Collector		-	-	-	
	Local	11	45,161	6,565	793	
	TOTAL	16	144,257	20,970	2,533	4.98

Baltimore - 1977 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
17	Freeway		0	0	0	
	Arterial	26	188, 183	27, 356	3, 305	
	Collector		-	-	-	
	Local	16	101, 022	14, 685	1, 774	
	TOTAL	22	289, 205	42, 041	5, 079	35. 5
18	Freeway		0	0	0	
	Arterial	26	324, 686	47, 198	5, 702	
	Collector		-	-	-	
	Local	16	153, 169	22, 265	2, 690	
	TOTAL	22	477, 855	69, 463	8, 392	37. 0
26	Freeway	44	93, 598	13, 606	1, 643	
	Arterial	25	108, 088	15, 713	1, 898	
	Collector		-	-	-	
	Local	15	62, 738	9, 120	1, 102	
	TOTAL	25	264, 424	38, 439	4, 643	11. 6
28	Freeway	47	90, 784	13, 197	1, 595	
	Arterial	27	111, 020	16, 139	1, 949	
	Collector		-	-	-	
	Local	17	70, 598	10, 262	1, 240	
	TOTAL	27	272, 402	39, 598	4, 784	22. 3
27	Freeway	47	157, 550	22, 902	2, 767	
	Arterial	28	72, 253	10, 503	1, 269	
	Collector		-	-	-	
	Local	16	41, 399	6, 018	727	
	TOTAL	32	271, 202	39, 423	4, 763	20. 5
29	Freeway	48	216, 131	31, 418	3, 795	
	Arterial	31	212, 186	30, 845	3, 726	
	Collector		-	-	-	
	Local	18	97, 668	14, 198	1, 715	
	TOTAL	31	525, 985	76, 461	9, 236	61. 2
39	Freeway	49	62, 925	9, 147	1, 105	
	Arterial	30	133, 688	19, 434	2, 348	
	Collector		-	-	-	
	Local	17	67, 593	9, 826	1, 187	
	TOTAL	27	264, 206	38, 407	4, 640	27. 8

Baltimore - 1977 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
	Freeway					VMT Total For All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		13,057,611	1,898,155	229,316	15,185,082
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					

Vehicle Miles of Travel (VMT)
Metropolitan Area Baltimore
Year 1977
Time Period 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway	30	18, 149	2, 638	319	
	Arterial	10	137, 046	19, 922	2, 407	
	Collector		-	-	-	
	Local	3	24, 794	3, 604	435	
	TOTAL	8	179, 989	26, 164	3, 161	. 554
10	Freeway		0	0	0	
	Arterial	16	102, 250	14, 864	1, 796	
	Collector		-	-	-	
	Local	7	32, 659	4, 748	573	
	TOTAL	13	134, 909	19, 612	2, 369	1, 14
11	Freeway		0	0	0	
	Arterial	23	26, 957	3, 919	473	
	Collector		-	-	-	
	Local	11	9, 744	1, 416	171	
	TOTAL	18	36, 701	5, 335	644	1. 61
12	Freeway	40	70, 451	10, 241	1, 237	
	Arterial	20	120, 093	17, 457	2, 109	
	Collector		-	-	-	
	Local	12	60, 213	8, 753	1, 057	
	TOTAL	20	250, 757	36, 451	4, 403	2. 20
13	Freeway	42	65, 627	9, 540	1, 152	
	Arterial	22	109, 762	15, 956	1, 927	
	Collector		-	-	-	
	Local	13	71, 274	10, 361	1, 252	
	TOTAL	20	246, 663	35, 857	4, 331	5. 07
20	Freeway	36	14, 564	2, 117	256	
	Arterial	18	128, 529	18, 684	2, 257	
	Collector		-	-	-	
	Local	9	42, 466	6, 173	746	
	TOTAL	15	185, 559	26, 974	3, 259	2. 17

Baltimore - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
21	Freeway	42	54, 892	7, 979	964	
	Arterial	23	48, 368	7, 031	849	
	Collector		-	-	-	
	Local	12	22, 993	3, 342	404	
	TOTAL	24	126, 253	18, 352	2, 217	2. 34
22	Freeway	42	54, 844	7, 972	963	
	Arterial	22	37, 219	5, 410	654	
	Collector		-	-	-	
	Local	12	15, 685	2, 280	275	
	TOTAL	25	107, 748	15, 662	1, 892	2. 24
30	Freeway		0	0	0	
	Arterial	17	85, 787	12, 471	1, 506	
	Collector		-	-	-	
	Local	8	32, 766	4, 763	575	
	TOTAL	13	118, 553	17, 234	2, 081	1. 13
31	Freeway		0	0	0	
	Arterial	19	106, 392	15, 466	1, 868	
	Collector		-	-	-	
	Local	9	47, 216	6, 864	829	
	TOTAL	14	153, 608	22, 330	2, 697	2. 93
32	Freeway	40	15, 005	2, 181	263	
	Arterial	20	106, 037	15, 414	1, 862	
	Collector		-	-	-	
	Local	11	53, 960	7, 844	948	
	TOTAL	16	175, 002	25, 439	3, 073	3. 91
33	Freeway	41	33, 802	4, 914	594	
	Arterial	21	132, 100	19, 203	2, 320	
	Collector		-	-	-	
	Local	11	62, 666	9, 110	1, 100	
	TOTAL	18	228, 568	33, 227	4, 014	5. 71
40	Freeway	35	56, 160	8, 164	986	
	Arterial	16	157, 176	22, 848	2, 760	
	Collector		-	-	-	
	Local	7	42, 178	6, 131	741	
	TOTAL	15	255, 514	37, 143	4, 487	1. 61

Baltimore - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
41	Freeway	36	76,830	11,169	1,349	
	Arterial	17	150,976	21,946	2,651	
	Collector		-	-	-	
	Local	9	64,725	9,408	1,137	
	TOTAL	16	292,531	42,523	5,137	2.97
42	Freeway		0	0	0	
	Arterial	17	191,789	27,880	3,368	
	Collector		-	-	-	
	Local	9	87,804	12,764	1,542	
	TOTAL	14	279,593	40,644	4,910	4.85
43	Freeway	39	125,035	18,176	2,196	
	Arterial	20	164,839	23,962	2,895	
	Collector		-	-	-	
	Local	12	81,520	11,850	1,432	
	TOTAL	20	371,394	53,988	6,523	4.95
50	Freeway	37	29,427	4,278	517	
	Arterial	17	144,021	20,936	2,529	
	Collector		-	-	-	
	Local	8	34,663	5,039	609	
	TOTAL	15	208,111	30,253	3,655	1.87
51	Freeway		0	0	0	
	Arterial	17	179,487	26,091	3,152	
	Collector		-	-	-	
	Local	9	72,174	10,492	1,267	
	TOTAL	14	251,661	36,583	4,419	2.96
52	Freeway		0	0	0	
	Arterial	20	140,718	20,456	2,471	
	Collector		-	-	-	
	Local	10	61,088	8,880	1,073	
	TOTAL	16	201,806	29,336	3,544	4.61
53	Freeway		0	0	0	
	Arterial	19	109,739	15,952	1,927	
	Collector		-	-	-	
	Local	10	50,824	7,388	892	
	TOTAL	15	160,563	23,340	2,819	4.01

Baltimore - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
60	Freeway		0	0	0	
	Arterial	17	87,247	12,683	1,532	
	Collector		-	-	-	
	Local	7	26,824	3,899	471	
	TOTAL	13	114,071	16,582	2,003	1.12
61	Freeway		0	0	0	
	Arterial	20	99,913	14,524	1,754	
	Collector		-	-	-	
	Local	10	34,819	5,062	612	
	TOTAL	16	134,732	19,586	2,366	2.21
62	Freeway		0	0	0	
	Arterial	22	93,929	13,654	1,649	
	Collector		-	-	-	
	Local	11	41,499	6,033	729	
	TOTAL	17	135,428	19,687	2,378	3.57
63	Freeway	40	51,968	7,554	913	
	Arterial	21	126,987	18,460	2,230	
	Collector		-	-	-	
	Local	11	42,857	6,230	753	
	TOTAL	20	221,812	32,244	3,896	4.54
64	Freeway	38	141,212	20,527	2,480	
	Arterial	20	154,167	22,411	2,707	
	Collector		-	-	-	
	Local	11	49,439	7,187	868	
	TOTAL	19	344,818	50,125	6,055	2.64
70	Freeway		0	0	0	
	Arterial	18	53,841	7,827	945	
	Collector		-	-	-	
	Local	8	18,044	2,623	317	
	TOTAL	14	71,885	10,450	1,262	1.14
71	Freeway	31	28,117	4,087	494	
	Arterial	13	157,592	22,909	2,767	
	Collector		-	-	-	
	Local	8	63,131	9,177	1,109	
	TOTAL	12	248,840	36,173	4,370	1.06

Baltimore - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
72	Freeway	40	19,877	2,889	349	
	Arterial	19	31,976	4,648	562	
	Collector		-	-	-	
	Local	10	18,511	2,691	325	
	TOTAL	18	70,364	10,228	1,236	1.01
73	Freeway	43	55,181	8,021	969	
	Arterial	22	38,073	5,535	669	
	Collector		-	-	-	
	Local	12	10,924	1,588	192	
	TOTAL	26	104,178	15,144	1,830	1.27
74	Freeway	40	22,726	3,304	399	
	Arterial	21	76,641	11,141	1,346	
	Collector		-	-	-	
	Local	11	36,127	5,252	634	
	TOTAL	18	135,494	19,697	2,379	2.73
23	Freeway	43	223,881	32,545	3,931	
	Arterial	23	112,451	16,347	1,975	
	Collector		-	-	-	
	Local	13	53,529	7,781	940	
	TOTAL	28	389,861	56,673	6,846	6.81
24	Freeway	42	151,260	21,988	2,656	
	Arterial	22	109,177	15,871	1,917	
	Collector		-	-	-	
	Local	12	52,149	7,581	916	
	TOTAL	24	312,586	45,440	5,489	5.07
25	Freeway	43	30,339	4,410	533	
	Arterial	23	61,619	8,957	1,082	
	Collector		-	-	-	
	Local	14	36,719	5,338	645	
	TOTAL	22	128,677	18,705	2,260	6.18
34	Freeway	38	169,168	24,591	2,971	
	Arterial	18	123,669	17,977	2,172	
	Collector		-	-	-	
	Local	10	63,836	9,280	1,121	
	TOTAL	20	356,673	51,848	6,264	3.92

Baltimore - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway	44	84,327	12,258	1,481	
	Arterial	25	87,220	12,679	1,532	
	Collector		-	-	-	
	Local	13	44,907	6,528	789	
	TOTAL	25	216,454	31,465	3,802	6.46
36	Freeway	41	182,321	26,503	3,202	
	Arterial	22	178,989	26,019	3,143	
	Collector		-	-	-	
	Local	13	103,902	15,104	1,825	
	TOTAL	23	465,212	67,626	8,170	10.1
37	Freeway	44	137,927	20,050	2,422	
	Arterial	25	212,261	30,855	3,727	
	Collector		-	-	-	
	Local	15	118,635	17,246	2,083	
	TOTAL	24	468,823	68,151	8,232	20.4
38	Freeway		0	0	0	
	Arterial	32	96,784	14,069	1,700	
	Collector		-	-	-	
	Local	20	46,504	6,760	817	
	TOTAL	27	143,288	20,829	2,517	25.3
44	Freeway	43	73,017	10,614	1,282	
	Arterial	23	90,488	13,154	1,589	
	Collector		-	-	-	
	Local	13	45,881	6,670	806	
	TOTAL	23	209,386	30,438	3,677	3.63
45	Freeway	43	168,222	24,454	2,954	
	Arterial	24	132,381	19,244	2,325	
	Collector		-	-	-	
	Local	14	79,813	11,602	1,402	
	TOTAL	25	380,416	55,300	6,681	8.79
46	Freeway	46	86,058	12,510	1,511	
	Arterial	27	207,123	30,109	3,637	
	Collector		-	-	-	
	Local	17	111,697	16,237	1,961	
	TOTAL	25	404,878	58,856	7,109	27.9

Baltimore - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
47	Freeway	50	69,626	10,121	1,223	
	Arterial	32	92,475	13,443	1,624	
	Collector		-	-	-	
	Local	19	55,397	8,053	973	
	TOTAL	30	217,498	31,617	3,820	21.3
48	Freeway		0	0	0	
	Arterial	31	153,779	22,354	2,700	
	Collector		-	-	-	
	Local	19	72,520	10,542	1,273	
	TOTAL	26	226,299	32,896	3,973	43.6
49	Freeway	54	22,058	3,207	387	
	Arterial	36	41,151	5,982	723	
	Collector		-	-	-	
	Local	22	25,688	3,734	451	
	TOTAL	33	88,897	12,923	1,561	23.8
54	Freeway	38	4,782	695	84	
	Arterial	19	183,647	26,696	3,225	
	Collector		-	-	-	
	Local	10	76,337	11,097	1,340	
	TOTAL	15	264,766	38,488	4,649	6.09
55	Freeway	40	39,348	5,720	691	
	Arterial	20	107,853	15,678	1,894	
	Collector		-	-	-	
	Local	11	54,969	7,992	965	
	TOTAL	18	202,170	29,390	3,550	3.36
56	Freeway	43	120,346	17,494	2,113	
	Arterial	23	261,607	38,029	4,594	
	Collector		-	-	-	
	Local	14	143,544	20,866	2,521	
	TOTAL	22	525,497	76,389	9,228	19.3
57	Freeway	43	114,226	16,605	2,006	
	Arterial	23	142,834	20,763	2,508	
	Collector		-	-	-	
	Local	14	77,787	11,308	1,366	
	TOTAL	23	334,847	48,676	5,880	11.3

Baltimore - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
58	Freeway	55	20,428	2,970	359	
	Arterial	38	70,563	10,257	1,239	
	Collector		-	-	-	
	Local	23	35,142	5,108	617	
	TOTAL	33	126,133	18,335	2,215	56.0
59	Freeway		0	0	0	
	Arterial	35	49,163	7,147	863	
	Collector		-	-	-	
	Local	20	19,530	2,839	343	
	TOTAL	29	68,693	9,986	1,206	22.4
65	Freeway	44	182,423	26,518	3,203	
	Arterial	24	111,754	16,245	1,963	
	Collector		-	-	-	
	Local	14	69,891	10,160	1,227	
	TOTAL	26	364,068	52,923	6,393	8.76
66	Freeway	42	154,603	22,474	2,715	
	Arterial	23	226,841	32,975	3,983	
	Collector		-	-	-	
	Local	13	119,392	17,356	2,097	
	TOTAL	22	500,836	72,805	8,795	11.1
67	Freeway	48	71,208	10,351	1,250	
	Arterial	29	133,592	19,420	2,346	
	Collector		-	-	-	
	Local	18	78,912	11,471	1,386	
	TOTAL	27	283,712	41,242	4,982	29.2
68	Freeway	47	75,195	10,931	1,320	
	Arterial	29	137,605	20,003	2,416	
	Collector		-	-	-	
	Local	17	75,495	10,974	1,326	
	TOTAL	27	288,295	41,908	5,062	19.8
75	Freeway	44	25,794	3,750	453	
	Arterial	24	40,671	5,912	714	
	Collector		-	-	-	
	Local	12	19,680	2,861	346	
	TOTAL	22	86,145	12,523	1,513	4.58

Baltimore - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
76	Freeway	41	62,821	9,132	1,103	
	Arterial	22	130,936	19,034	2,299	
	Collector		-	-	-	
	Local	12	58,380	8,487	1,025	
	TOTAL	21	252,137	36,653	4,427	6.24
77	Freeway	44	103,983	15,116	1,826	
	Arterial	24	99,701	14,493	1,751	
	Collector		-	-	-	
	Local	14	55,903	8,126	982	
	TOTAL	24	259,587	37,735	4,559	12.0
78	Freeway	45	37,050	5,386	651	
	Arterial	25	100,877	14,664	1,771	
	Collector		-	-	-	
	Local	14	55,358	8,047	972	
	TOTAL	22	193,285	28,097	3,394	11.6
79	Freeway		0	0	0	
	Arterial	28	58,466	8,499	1,027	
	Collector		-	-	-	
	Local	16	26,886	3,908	472	
	TOTAL	23	85,352	12,407	1,499	14.4
14	Freeway	43	123,253	17,917	2,164	
	Arterial	23	284,488	41,355	4,996	
	Collector		-	-	-	
	Local	14	150,094	21,819	2,636	
	TOTAL	22	557,835	81,091	9,796	14.7
15	Freeway		0	0	0	
	Arterial	28	78,248	11,375	1,374	
	Collector		-	-	-	
	Local	17	36,421	5,294	640	
	TOTAL	23	114,669	16,669	2,014	12.4
16	Freeway		0	0	0	
	Arterial	20	132,128	19,207	2,320	
	Collector		-	-	-	
	Local	11	60,214	8,753	1,057	
	TOTAL	16	192,342	27,960	3,377	4.98

Baltimore - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
17	Freeway		0	0	0	
	Arterial	26	250,910	36,474	4,406	
	Collector		-	-	-	
	Local	16	134,696	19,580	2,365	
	TOTAL	22	385,606	56,054	6,771	35.5
18	Freeway		0	0	0	
	Arterial	26	432,915	62,931	7,602	
	Collector		-	-	-	
	Local	16	204,225	29,687	3,586	
	TOTAL	22	637,140	92,618	11,188	37.0
26	Freeway	44	124,797	18,141	2,191	
	Arterial	25	144,117	20,950	2,531	
	Collector		-	-	-	
	Local	15	83,651	12,160	1,469	
	TOTAL	25	352,565	51,251	6,191	11.6
28	Freeway	47	121,045	17,596	2,126	
	Arterial	27	148,026	21,518	2,599	
	Collector		-	-	-	
	Local	17	94,130	13,683	1,653	
	TOTAL	27	363,201	52,797	6,378	22.3
27	Freeway	47	210,066	30,536	3,689	
	Arterial	28	96,337	14,004	1,692	
	Collector		-	-	-	
	Local	16	55,199	8,024	969	
	TOTAL	32	361,602	52,564	6,350	20.5
29	Freeway	48	288,174	41,891	5,060	
	Arterial	31	282,915	41,126	4,968	
	Collector		-	-	-	
	Local	18	130,224	18,930	2,287	
	TOTAL	31	701,313	101,947	12,315	61.2
39	Freeway	49	83,900	12,196	1,473	
	Arterial	30	178,250	25,912	3,130	
	Collector		-	-	-	
	Local	17	90,124	13,101	1,583	
	TOTAL	27	352,274	51,209	6,186	27.8

Baltimore - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
	Freeway		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		17,410,123	2,530,847	305,729	20,246,699
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					

APPENDIX B

UNADJUSTED VEHICLE AGE DISTRIBUTION DATA

TABLE B-1

MODEL-YEAR DISTRIBUTION - R.L. POLK DATA

(As of July 1, 1971)

Model Year	Passenger Cars	Percent	Trucks	Percent
1971	79,849	9.7	9,455	9.1
1970	143,169	17.3	15,022	14.5
1969	101,398	12.3	12,404	12.0
1968	88,392	10.7	8,808	8.5
1967	76,617	9.3	8,470	8.2
1966	76,564	9.3	8,551	8.3
1965	72,273	8.8	6,979	6.8
1964	59,461	7.2	6,069	5.9
1963	46,537	5.6	4,648	4.5
1962	31,492	3.9	3,764	3.6
1961	16,867	2.0	2,729	2.6
1960	11,459	1.4	2,438	2.4
1959	5,380	.6	2,000	1.9
1958	2,596	.3	1,267	1.2
1957	3,150	.4	1,512	1.5
1956	2,363	.3	1,541	1.5
Prior	7,650	.9	7,728	7.5
TOTAL	825,217	100.0	103,468	100.0

TABLE B-2

AGE DISTRIBUTION - MARYLAND STATE DATA

(As of June 7, 1971)

Vehicle Age (Years)	Percent
< 1	4.6
1-2	13.1
2-3	12.7
3-4	11.4
4-5	10.0
5-6	10.2
6-7	9.8
7-8	8.0
8-9	6.6
9 & Over	13.6

APPENDIX C

ESTIMATED POLLUTANT EMISSIONS

APPENDIX C

ESTIMATED POLLUTANT EMISSIONS

The emissions estimates for 1970 and 1977 tabulated herein were calculated from the District-level VMT data in Appendix A by the same procedure (same computer program) as the estimates in other studies in this series. The totals for each pollutant and year at the bottom of the tables are calculated as a single calculation for the entire study area; the slight difference between these totals and the sum of the District figures has been absorbed into the figures for the Suburban Analysis Area.

Similar calculations have been made by the Maryland State Bureau of Air Quality Control with the same input data, but with a different emissions calculation procedure and with the different age distribution data already described.

The principal difference in the resulting estimates is that projected 1977 hydrocarbon emissions from the BAQC calculations are much lower than the GCA calculations. This difference is believed due to the BAQC combining of heavy-duty VMT and light-duty VMT in one age-distribution array, and adjustments exterior to the BAQC computer program are used to correct this effect.

TABLE C - 1
1970 CARBON MONOXIDE EMISSIONS

VEHICLE CATEGORY → ZONE NO.	AREA (SQ.MI)	LIGHT DUTY EMISSIONS (KGM)	LIGHT DUTY EMISSION DENSITY (KGM/SQ.MI)	HEAVY DUTY EMISSIONS (KGM)	HEAVY DUTY EMISSION DENSITY (KGM/SQ.MI)	OTHER EMISSIONS (KGM)	OTHER EMISSION DENSITY (KGM/SQ.MI)	TOTAL EMISSIONS (KGM)	TOTAL EMISSION DENSITY (KGM/SQ.MI)
1	0.554	11344.51	20477.45	2573.08	4644.54	33.70	60.82	13951.28	25182.81
10	1.140	8833.74	7748.90	2003.59	1757.53	31.80	27.89	10869.13	9534.32
11	1.610	2240.62	1391.69	508.19	315.64	9.39	5.83	2758.19	1713.16
12	2.200	14772.45	6714.75	3350.84	1523.02	69.88	31.77	18192.98	8269.62
13	5.070	12452.21	2456.06	2824.42	557.08	56.27	11.10	15332.89	3024.24
14	14.700	30404.21	2068.31	6896.38	469.14	149.09	10.14	37449.68	2547.60
15	12.400	2315.54	186.74	525.18	42.35	13.27	1.07	2853.99	230.16
16	4.980	12222.77	2454.37	2772.40	556.71	48.17	9.67	15043.33	3020.75
17	35.500	13910.08	391.83	3155.09	88.88	70.50	1.99	17135.66	482.69
18	37.000	27503.41	743.34	6238.43	168.61	142.09	3.84	33883.93	915.78
19	No District 19								
20	2.170	11962.15	5512.51	2713.28	1250.36	44.45	20.49	14719.88	6783.35
21	2.340	6389.84	2730.70	1449.33	619.37	28.51	12.18	7867.67	3362.25
22	2.240	5109.80	2281.16	1158.95	517.39	20.21	9.02	6288.96	2807.57
23	6.810	17259.48	2534.43	3914.87	574.87	97.40	14.30	21271.75	3123.60
24	5.070	16186.93	3192.69	3671.57	724.18	73.09	14.42	19931.59	3931.28
25	6.180	5550.97	898.22	1259.00	203.72	26.10	4.22	6836.07	1106.16
26	11.600	16841.42	1451.85	3820.06	329.31	92.75	8.00	20754.23	1789.16
27	20.500	8215.65	400.76	1863.44	90.90	44.72	2.18	10123.80	493.84
28	22.300	12219.17	547.94	2771.57	124.29	78.48	3.52	15069.19	675.75
29	61.200	20071.52	327.97	4552.67	74.39	118.01	1.93	24742.20	404.28
30	1.130	8373.21	7409.92	1899.15	1680.66	30.88	27.33	10303.21	9117.89
31	2.930	10844.80	3701.30	2459.85	839.54	40.86	13.95	13345.51	4554.78
32	3.910	10542.53	2696.30	2391.24	611.57	40.70	10.41	12974.46	3318.28
33	5.710	14823.75	2596.10	3362.27	588.84	58.35	10.22	18244.38	3195.16
34	3.920	18836.78	4805.30	4272.52	1089.93	82.86	21.14	23192.16	5916.37
35	6.160	11684.34	1896.81	2650.22	430.23	55.84	9.07	14390.40	2336.10
36	10.100	22170.94	2195.14	5028.91	497.91	118.87	11.77	27318.72	2704.83
37	20.400	20066.53	983.65	4551.54	223.11	102.87	5.04	24720.93	1211.81
38	25.300	2431.48	96.11	551.50	21.80	14.16	0.56	2997.15	118.46
39	27.800	11770.59	423.40	2669.78	96.04	70.97	2.55	14511.33	521.99
40	1.610	16884.61	10487.33	3829.74	2378.72	66.74	41.45	20781.08	12907.50
41	2.970	17809.25	5996.38	4039.52	1360.11	75.46	25.41	21924.22	7381.89
42	4.850	20668.67	4261.58	4688.09	966.62	75.21	15.51	25431.96	5243.70
43	4.950	19434.30	3926.12	4408.13	890.53	91.82	18.55	23934.26	4835.20
44	3.630	11742.78	3234.93	2663.46	733.74	58.35	16.07	14464.59	3984.74
45	8.790	18828.69	2142.06	4270.72	485.86	106.78	12.15	23206.19	2640.07
46	27.900	14266.68	511.35	3235.99	115.99	82.27	2.95	17584.94	630.28
47	21.300	8198.02	384.88	1859.49	87.30	54.76	2.57	10112.26	474.75
48	43.600	7255.66	166.41	1645.70	37.75	42.51	0.98	8943.87	205.13
49	23.800	2013.81	84.61	456.78	19.19	14.76	0.62	2485.34	104.43
50	1.870	18115.98	9687.69	4109.11	2197.39	65.76	35.17	22290.85	11920.24
51	2.960	18300.27	6182.52	4150.89	1402.33	67.19	22.70	22518.34	7607.55
52	4.610	13731.03	2978.53	3114.49	675.59	53.27	11.56	16898.79	3665.68
53	4.010	10220.42	2548.73	2318.20	578.11	39.41	9.83	12578.03	3136.67
54	6.090	18797.34	3086.59	4263.55	700.09	71.86	11.80	23132.75	3798.48
55	3.360	14028.97	4175.29	3182.09	947.05	59.58	17.73	17270.64	5140.07
56	19.300	29742.13	1541.04	6746.13	349.54	144.09	7.47	36632.35	1898.05
57	11.300	15197.37	1344.90	3447.12	305.06	80.82	7.15	18725.31	1657.11
58	56.000	4138.62	73.90	938.71	16.76	28.86	0.52	5106.18	91.18
59	22.400	1703.71	76.06	386.36	17.25	10.84	0.48	2100.91	93.79
60	1.120	8172.07	7296.49	1853.63	1655.02	29.47	26.31	10055.17	8977.83
61	2.210	9035.34	4088.39	2049.33	927.30	35.78	16.19	11120.45	5031.88
62	3.570	8378.99	2347.06	1900.49	532.35	33.68	9.43	10313.15	2888.84
63	4.540	12387.79	2728.59	2809.76	618.89	54.62	12.03	15252.17	3359.51
64	2.640	19358.75	7332.86	4390.95	1663.24	81.48	30.86	23831.18	9026.96
65	8.760	17863.73	2039.24	4051.85	462.54	101.74	11.61	22017.32	2513.39
66	11.100	21270.77	1916.29	4824.63	434.65	108.99	9.82	26204.39	2360.76
67	29.200	9876.89	338.25	2240.31	76.72	60.25	2.06	12177.45	417.04
68	19.800	9798.75	494.89	2222.54	112.25	62.11	3.14	12083.39	610.27
69	No District 69								
70	1.140	4453.06	3906.20	1010.01	885.97	17.16	15.06	5480.23	4807.22
71	1.060	19791.45	18671.19	4489.17	4235.06	67.39	63.58	24348.01	22969.83
72	1.010	3403.96	3370.26	772.05	764.41	15.47	15.32	4191.47	4149.97
73	1.270	4420.65	3480.83	1002.62	789.47	19.74	15.54	5443.00	4285.83
74	2.730	7861.39	2879.63	1783.13	653.16	34.49	12.63	9679.02	3545.43
75	4.580	6396.64	1397.08	1451.27	316.87	29.59	6.46	7878.50	1720.20
76	6.240	17450.46	2796.55	3958.17	634.32	69.23	11.09	21477.86	3441.96
77	12.000	10995.10	916.26	2493.87	207.82	52.17	4.35	13541.13	1128.43
78	11.600	10943.10	943.37	2482.04	213.97	47.58	4.10	13472.72	1161.44
79	14.400	2771.93	192.50	628.67	43.66	14.43	1.00	3415.03	237.15
TOTAL	777.900	905645.06	1164.17	205308.81	264.06	4097.63	5.26	[illegible]	1433.40

TABLE C - 2

1977 CARBON MONOXIDE EMISSIONS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
[illegible] 1	0.954	5086.48	9181.36	2993.63	5403.55	54.50	116.42	8144.59	·701.43
10	1.140	3449.38	3025.77	2069.79	1815.60	49.35	42.41	5567.51	4883.78
11	1.610	788.26	489.60	491.11	305.04	13.14	8.16	1292.51	802.80
12	2.200	5063.46	2301.57	3200.96	1454.98	89.87	40.85	8354.29	3797.40
13	5.070	4866.70	959.90	3094.03	610.26	88.40	17.44	8049.12	1587.60
14	14.700	10680.75	726.58	6841.29	465.39	199.92	13.60	17721.96	1205.58
15	12.400	2069.89	166.93	1346.06	108.55	41.09	3.31	3457.04	278.79
16	4.980	4458.18	895.22	2730.52	548.30	58.92	13.06	7257.61	1457.35
17	35.500	7474.91	210.56	4773.01	134.45	138.20	3.89	12386.11	348.90
18	37.000	12218.44	330.23	7825.10	211.54	228.35	6.17	20269.89	547.83
19	No District 19								
20	2.170	4296.63	1980.01	2632.23	1213.01	66.50	30.64	6995.35	3223.67
21	2.340	2243.90	958.93	1465.17	626.14	45.25	19.34	3754.31	1604.41
22	2.240	1815.23	810.37	1202.57	536.86	38.62	17.24	3056.42	1364.47
23	6.810	6142.77	902.02	4146.41	608.87	139.73	20.52	10428.90	1531.41
24	5.070	5393.23	1063.76	3549.80	700.17	112.05	22.10	9055.15	1786.03
25	6.180	2467.19	399.22	1579.73	255.62	46.11	7.46	4093.03	662.30
26	11.600	6014.27	518.47	3970.88	342.32	126.36	10.89	10111.51	871.68
27	10.500	5094.32	248.50	3557.83	173.55	129.58	6.32	8781.73	428.38
28	22.300	5877.23	263.55	3938.10	176.60	130.17	5.84	9945.50	445.99
29	61.200	9969.20	162.90	6942.91	113.45	251.35	4.11	17163.45	280.45
30	1.130	2962.35	2621.56	1785.81	1580.36	42.47	37.59	4790.62	4239.48
31	2.930	3643.39	1243.48	2220.46	757.84	55.05	18.79	5918.89	2020.10
32	3.910	4018.99	1027.88	2466.54	630.83	62.72	16.04	6548.25	1674.75
33	5.710	4859.18	850.99	3034.53	531.44	81.91	14.34	7975.61	1396.78
34	3.920	6773.62	1727.96	4347.62	1109.09	127.83	32.61	11249.06	2869.66
35	6.160	3723.66	604.49	2452.84	398.19	77.56	12.59	6254.06	1015.27
36	10.100	8510.07	842.58	5514.88	546.03	166.73	16.51	14191.68	1405.12
37	20.400	8214.11	402.65	5381.47	263.79	167.87	8.23	13763.39	674.68
38	25.300	2299.97	90.91	1544.66	61.05	51.35	2.03	3895.99	153.99
39	27.800	5555.03	199.82	3749.87	134.89	126.26	4.54	9431.15	339.25
40	1.610	5812.73	3610.39	3574.85	2220.41	91.56	56.87	9479.14	5887.66
41	2.970	6430.63	2165.20	3985.22	1341.82	104.83	35.29	10520.67	3542.31
42	4.850	7057.00	1455.05	4245.57	875.38	100.19	20.66	11402.77	2351.09
43	4.950	7288.95	1472.52	4640.07	937.39	133.09	26.89	12062.12	2436.79
44	3.630	3801.02	1047.11	2468.15	679.93	75.03	20.67	6344.19	1747.71
45	8.790	6433.09	731.86	4257.63	484.37	136.34	15.51	10827.05	1231.75
46	27.900	6886.63	246.83	4551.78	163.15	145.09	5.20	11583.50	415.18
47	21.300	3182.47	149.41	2196.66	103.13	77.95	3.66	5457.07	256.20
48	43.600	3724.72	85.43	2483.79	56.97	81.09	1.86	6289.59	144.26
49	23.800	1243.58	52.25	870.41	36.57	31.86	1.34	2145.85	90.16
50	1.870	4747.99	2539.03	2918.15	1560.51	74.53	39.88	7740.72	4139.42
51	2.960	6306.80	2130.68	3799.71	1283.69	90.19	30.47	10196.70	3444.83
52	4.610	4658.11	1010.44	2855.57	619.43	72.31	15.69	7586.00	1645.55
53	4.010	3822.42	953.22	2327.75	580.49	57.54	14.35	6207.70	1548.06
54	6.090	6196.93	1017.56	3787.49	621.92	94.89	15.58	10079.30	1655.06
55	3.360	4290.83	1277.03	2680.65	797.81	72.46	21.56	7043.94	2096.41
56	19.300	10049.39	520.69	6438.84	333.62	188.37	9.76	16676.55	864.07
57	11.300	6026.45	533.31	3922.10	347.09	119.99	10.62	10068.53	891.02
58	56.000	1737.54	31.03	1222.12	21.82	45.19	0.81	3004.85	53.66
59	22.400	1050.28	46.89	715.39	31.94	24.61	1.10	1790.29	79.92
60	1.120	2819.26	2517.19	1703.44	1520.93	40.88	36.50	4563.58	4074.62
61	2.210	3051.46	1380.75	1878.46	849.98	48.27	21.84	4978.20	2252.58
62	3.570	3024.39	847.17	1867.61	523.14	48.53	13.60	4940.53	1383.90
63	4.540	4393.96	967.83	2790.09	614.55	79.50	17.51	7263.53	1599.90
64	2.640	6159.51	2333.15	3909.21	1480.76	110.99	42.04	10179.70	3855.95
65	8.760	5916.38	675.39	3959.53	452.00	130.48	14.90	10006.39	1142.28
66	11.100	9362.00	843.42	6033.23	543.53	179.49	16.17	15574.71	1403.13
67	29.200	4513.23	154.56	3035.95	104.07	101.69	3.48	7653.86	262.12
68	19.800	4631.59	233.92	3109.81	157.06	103.32	5.22	7844.71	396.20
69	No District 69								
70	1.140	1726.94	1514.91	1049.61	920.71	25.76	22.59	2802.36	2458.[illegible]
71	1.060	6727.38	6346.59	3992.61	3766.61	89.17	84.12	10809.16	10197.32
72	1.010	1464.67	1449.97	918.88	909.78	25.21	24.96	2408.56	2384.71
73	1.270	1680.48	1323.21	1126.97	887.38	37.33	29.39	2844.77	2239.98
74	2.730	2858.13	1046.93	1788.58	655.16	48.55	17.79	4695.26	1719.87
75	4.580	1599.68	349.28	1032.35	225.40	30.86	6.74	2662.89	581.42
76	6.240	4974.85	797.25	3162.78	506.86	90.35	14.48	8227.98	1318.59
77	12.000	4445.24	370.44	2931.91	244.33	93.03	7.75	7470.18	622.51
78	11.600	3636.36	313.48	2339.57	201.69	69.27	5.97	6045.21	521.14
79	14.400	1567.37	108.85	1014.49	70.46	30.57	2.12	2612.44	181.43
[illegible]	777.900	343630.31	441.97	218333.56	280.82	6227.25	8.01	568196.13	730.40

TABLE C - 3

1970 HYDROCARBON EMISSIONS

VEHICLE CATEGORY =		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
CBD 1	0.554	1464.54	2643.57	435.31	785.77	5.54	10.00	1905.40	3439.34
10	1.140	1252.32	1098.53	364.88	320.07	5.23	4.59	1622.43	1423.18
11	1.610	341.49	212.11	97.71	60.69	1.54	0.96	440.75	273.76
12	2.200	2366.91	1075.87	665.49	302.49	11.49	5.22	3043.89	1383.59
13	5.070	1948.45	384.31	550.97	108.67	9.26	1.83	2508.67	494.81
14	14.700	4969.25	338.04	1391.41	94.65	24.51	1.67	6385.17	434.37
15	12.400	415.68	33.52	114.39	9.22	2.18	0.18	532.25	42.92
16	4.980	1788.08	359.05	514.15	103.24	7.92	1.59	2310.15	463.89
17	35.500	2330.10	65.64	650.97	18.34	11.60	0.33	2992.66	84.30
18	37.000	4659.57	125.93	1299.06	35.11	23.37	0.63	5981.99	161.68
19	No District 19								
20	2.170	1725.18	795.01	501.07	230.91	[illegible]	3.37	2233.56	1029.29
21	2.340	993.50	424.57	281.34	120.23	4.69	2.00	1279.54	546.81
22	2.240	748.95	334.35	215.25	96.09	3.32	1.48	967.53	431.93
23	6.810	3039.76	446.37	835.87	122.74	16.02	2.35	3891.64	571.46
24	5.070	2530.80	499.13	715.54	141.13	12.02	2.37	3258.16	642.64
25	6.180	887.65	143.63	249.82	40.42	4.29	0.69	1141.77	184.75
26	11.600	2931.46	252.71	808.93	69.74	15.26	1.32	3755.64	323.76
27	20.500	1435.50	70.02	397.85	19.41	7.36	0.36	1840.70	89.79
28	22.300	2328.78	104.43	630.84	29.29	12.90	0.58	2972.52	133.30
29	61.200	3658.13	59.77	1003.91	16.40	19.41	0.32	4681.45	76.49
30	1.130	1204.80	1066.02	350.29	309.99	5.09	4.49	1559.97	1380.51
31	2.930	1581.98	539.93	459.22	156.73	6.72	2.29	2047.92	698.95
32	3.910	1541.41	394.22	445.25	113.87	6.69	1.71	1993.36	509.81
33	5.710	2189.09	383.38	630.98	110.50	9.60	1.68	2829.67	495.56
34	3.920	2924.91	746.15	831.01	211.99	13.63	3.48	3769.55	961.62
35	6.160	1882.62	305.62	528.68	85.82	9.19	1.49	2420.48	392.94
36	10.100	3758.80	372.16	1042.39	103.21	19.22	1.90	4820.41	477.27
37	20.400	3364.36	164.92	937.27	45.94	16.92	0.83	4318.54	211.69
38	25.300	440.17	17.40	120.85	4.78	2.33	0.09	563.34	22.27
39	27.800	2166.58	77.93	591.93	21.29	11.67	0.42	2770.18	99.65
40	1.610	2490.95	1547.17	717.15	445.43	10.98	6.82	3219.07	1999.42
41	2.970	2735.10	920.91	782.10	263.33	12.4[illegible]	4.18	3527.61	1188.42
42	4.850	2962.09	610.74	863.08	177.95	12.37	2.55	3837.54	791.25
43	4.950	3110.03	628.29	874.45	176.66	15.13	3.05	3999.58	808.00
44	3.630	1930.12	531.71	539.29	148.56	9.60	2.64	2479.01	682.92
45	8.790	3325.08	378.28	913.66	103.94	17.55	2.00	4256.29	484.22
46	27.900	2566.42	91.99	705.58	25.29	13.53	0.49	3285.54	117.76
47	21.300	1598.39	75.04	430.74	20.22	9.01	0.42	2038.14	95.69
48	43.600	1319.92	30.27	362.35	8.31	6.99	0.16	1689.26	38.74
49	23.800	414.60	17.42	110.35	4.64	2.43	0.10	527.37	22.16
50	1.870	2566.73	1372.58	746.43	399.16	10.82	5.78	3323.98	1777.53
51	2.960	2629.81	888.45	765.20	258.51	11.05	3.73	3406.06	1150.70
52	4.610	2033.33	441.07	588.38	127.63	8.75	1.90	2630.47	570.60
53	4.010	1510.05	376.57	437.35	109.06	6.43	1.62	1953.88	487.25
54	6.090	2758.16	452.90	799.09	131.21	11.82	1.94	3569.07	586.05
55	3.360	2145.49	638.54	612.55	182.31	9.80	2.92	2767.84	823.76
56	19.300	4827.24	250.12	1353.42	70.13	23.70	1.23	6204.36	321.47
57	11.300	2592.06	229.39	718.25	63.56	13.29	1.18	3323.60	294.12
58	56.000	827.97	14.79	221.88	3.96	4.75	0.08	1054.59	18.83
59	22.400	323.81	14.46	87.88	3.92	1.78	0.08	413.47	18.46
60	1.120	1159.11	1034.92	337.63	301.46	4.85	4.33	1501.59	1340.71
61	2.210	1347.93	609.93	388.90	175.97	5.88	2.66	1742.72	788.56
62	3.570	1250.83	350.37	359.70	100.76	5.54	1.55	1616.07	452.68
63	4.540	1932.06	425.56	549.19	120.97	8.95	1.98	2490.23	548.51
64	2.640	2947.75	1116.57	842.53	319.14	13.40	5.08	3803.68	1440.79
65	8.760	3158.68	360.58	867.20	99.00	16.73	1.91	4042.61	461.49
66	11.100	3559.74	320.70	991.30	89.31	17.93	1.61	4568.96	411.62
67	29.200	1828.18	62.61	498.54	17.07	9.91	0.34	2336.63	80.02
68	19.800	1855.96	93.74	503.77	25.44	10.22	0.52	2369.95	119.69
69	No District 69								
70	1.140	654.54	574.15	189.36	166.11	2.82	2.48	846.72	742.74
71	1.060	2734.13	2579.37	801.67	756.29	11.09	10.46	3546.88	3346.12
72	1.010	538.50	533.17	152.43	150.92	2.54	2.52	693.47	686.61
73	1.270	687.94	541.68	194.82	153.40	3.25	2.56	886.00	697.64
74	2.730	1212.71	444.22	344.19	126.08	5.67	2.08	1562.57	572.37
75	4.580	1005.34	219.51	285.32	62.30	4.70	1.03	1295.37	282.83
76	6.240	2561.46	410.49	735.98	117.94	11.39	1.82	3308.82	530.26
77	12.000	1766.19	147.18	496.53	41.38	8.58	0.72	2271.30	189.28
78	11.600	1683.49	145.13	478.58	41.26	7.83	0.67	2169.90	187.06
79	14.400	471.72	32.76	131.37	9.12	2.37	0.16	605.47	42.05
TOTAL	777.500	141577.69	182.09	40037.57	51.50	672.3[illegible]	0.86	182287.96	234.45

TABLE C - 4

1977 HYDROCARBON EMISSIONS

VEHICLE CATEGORY		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
CBD 1	0.554	642.28	1159.35	509.42	919.53	10.61	19.15	1162.31	2098.03
10	1.140	432.64	379.51	346.69	304.11	7.95	6.98	787.28	690.60
11	1.610	105.78	65.70	85.73	53.25	2.16	1.34	193.67	120.29
12	2.200	687.44	312.47	560.28	254.67	14.78	6.72	1262.51	573.87
13	5.070	666.86	131.53	544.37	107.37	14.56	2.87	1225.79	241.76
14	14.700	1483.67	100.93	1213.54	82.55	32.88	2.24	2730.09	185.72
15	12.400	297.50	23.99	244.06	19.68	6.76	0.54	548.33	44.22
16	4.980	579.74	116.41	467.54	93.88	11.34	2.28	1058.62	212.57
17	35.500	1038.29	29.25	848.00	23.89	22.73	0.64	1909.02	53.78
18	37.000	1705.85	46.10	1394.17	37.68	37.56	1.02	3137.58	84.80
19	No District 19								
20	2.170	561.19	258.61	452.43	208.49	10.94	5.04	1024.55	472.15
21	2.340	321.50	137.39	264.35	112.97	7.44	3.18	593.29	253.54
22	2.240	266.33	118.90	219.80	98.13	6.35	2.84	492.49	219.86
23	6.810	928.21	136.30	769.61	113.01	22.98	3.37	1720.80	252.69
24	5.070	782.77	154.39	644.98	127.21	18.43	3.63	1446.17	285.24
25	6.180	342.35	55.40	280.00	45.31	7.58	1.23	629.94	101.93
26	11.600	877.99	75.69	723.94	62.41	20.78	1.79	1622.71	139.89
27	20.500	811.96	39.61	678.70	33.11	21.31	1.04	1511.97	73.75
28	22.300	880.46	39.48	728.49	32.67	21.41	0.96	1630.36	73.11
29	61.200	1590.68	25.99	1327.78	21.70	41.34	0.68	2959.80	48.36
30	1.130	375.19	332.03	301.77	267.05	7.99	7.07	684.95	606.15
31	2.930	474.43	161.92	381.64	130.25	9.05	3.09	865.12	295.26
32	3.910	523.61	133.92	422.67	108.09	10.32	2.64	956.54	244.64
33	5.710	653.08	114.37	529.77	92.78	13.47	2.36	1196.31	209.51
34	3.920	957.46	244.25	782.27	199.56	21.02	5.36	1760.75	449.17
35	6.160	541.48	87.90	446.21	72.44	12.76	2.07	1000.45	162.41
36	10.100	1204.65	119.27	988.49	97.87	27.42	2.72	2220.56	219.86
37	20.400	1185.11	58.09	975.03	47.80	27.61	1.35	2187.74	107.24
38	25.300	349.51	13.81	288.95	11.42	8.45	0.33	646.90	25.57
39	27.800	846.06	30.43	700.86	25.21	20.77	0.75	1567.69	56.39
40	1.610	759.79	471.92	613.65	381.15	15.06	9.35	1388.51	862.43
41	2.970	856.69	288.45	693.05	233.35	17.24	5.81	1566.98	527.60
42	4.850	895.04	184.54	717.35	147.91	16.48	3.40	1628.87	335.85
43	4.950	1001.93	202.41	818.13	165.28	21.90	4.42	1841.96	372.11
44	3.630	539.73	148.69	443.13	122.07	12.34	3.40	995.20	274.16
45	8.790	942.03	107.17	777.09	88.41	22.42	2.55	1741.54	198.16
46	27.900	1011.38	36.25	833.79	29.88	23.86	0.86	1869.03	66.99
47	21.300	501.11	23.53	417.39	19.60	12.82	0.60	931.32	43.72
48	43.600	559.70	12.84	461.90	10.59	13.34	0.31	1034.93	23.74
49	23.800	200.01	8.40	167.13	7.02	5.24	0.22	372.38	15.65
50	1.870	620.19	331.65	500.78	267.80	12.27	6.56	1133.24	606.01
51	2.960	800.61	270.48	642.05	216.91	14.85	5.02	1457.51	492.40
52	4.610	613.70	133.12	494.46	107.26	11.89	2.58	1120.05	242.96
53	4.010	491.42	122.55	395.68	98.67	9.46	2.36	896.56	223.58
54	6.090	810.19	133.04	652.35	107.12	15.61	2.56	1478.15	242.72
55	3.360	576.67	171.63	467.88	139.25	11.92	3.55	1056.47	314.42
56	19.300	1396.43	72.35	1142.30	59.19	30.98	1.60	2569.71	133.15
57	11.300	858.88	76.01	705.58	62.44	19.74	1.75	1584.20	140.19
58	56.000	281.66	5.03	235.61	4.21	7.43	0.13	524.70	9.37
59	22.400	162.74	7.27	135.05	6.03	4.05	0.18	301.84	13.48
60	1.120	358.52	320.11	287.89	257.04	6.72	6.00	653.13	583.15
61	2.210	403.93	182.77	325.95	147.49	7.94	3.59	737.82	333.85
62	3.570	399.60	111.93	323.00	90.48	7.98	2.24	730.58	204.65
63	4.540	611.60	134.71	498.05	109.70	13.08	2.88	1122.73	247.30
64	2.640	849.17	321.65	692.21	262.20	18.26	6.91	1559.64	590.77
65	8.760	880.97	100.57	729.07	83.23	21.46	2.45	1631.50	186.24
66	11.100	1313.65	118.35	1076.27	96.96	29.52	2.66	2419.44	217.97
67	29.200	684.17	23.43	566.46	19.40	16.72	0.57	1267.36	43.40
68	19.800	698.40	35.27	577.89	29.19	16.99	0.86	1293.28	65.32
69	No District 69								
70	1.140	222.61	195.27	179.01	157.03	4.25	3.72	405.85	356.01
71	1.060	828.21	781.33	661.21	623.79	14.67	13.84	1504.09	1418.95
72	1.010	200.20	198.22	162.44	160.83	4.15	4.11	366.79	363.16
73	1.270	251.40	197.95	208.12	163.87	6.14	4.83	465.66	366.66
74	2.730	385.40	141.17	312.86	114.60	7.99	2.93	706.25	258.70
75	4.580	225.02	49.13	184.41	40.26	5.07	1.11	414.50	90.50
76	6.240	682.68	109.40	557.21	89.30	14.86	2.38	1254.75	201.08
77	12.000	647.17	53.93	533.55	44.46	15.30	1.28	1196.02	99.67
78	11.600	509.31	43.91	417.05	35.95	11.39	0.98	937.76	80.84
79	14.400	223.38	15.51	183.06	12.71	5.03	0.35	411.47	28.57
TOTAL	777.300	47061.98	60.55	38410.85	49.42	1024.25	1.32	86497.08	111.28

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